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ENVIRONMENTAL IMPACT STATEMENT APPENDICES

HORSE DRAW
OIL SHALE RESEARCH TRACT
RIO BLANCO COUNTY, COLORADO



U.S. BUREAU OF MINES
DENVER, COLORADO

prepared by VTN IRVINE, CALIFORNIA

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OIL SHALE RESEARCH TRACT

APPENDIX TO

DRAFT ENVIRONMENTAL IMPACT STATEMENT

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August, 1980

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APPENDIX A

ECOLOGY

APPENDIX A

Topoedaphic Description, Structure, and Composition of Terrestrial Plant Communities

The common and scientific names of the plant species mentioned below, as well as most of the other species expected to occur within the study area are incorporated by reference to Tables XI-37 and XI-39 of "Oil Shale Tract C-b, Detailed Development Plan and Related Materials, vol. 2 of 2" (Ashland Oil, Inc. 1976). See also Table 1 for species noted during site visit.

(1) Pinyon-Juniper Woodlands

In this part of western Colorado, the most common vegetation present is pinyon-juniper woodland. Local soil, temperature, topographic, and moisture conditions are the cause of the mosaic of plant communities found within and adacent to the study area.

Within the study area, this community occurs primarily on ridges and dry slopes and is usually absent from loamy soils of the uplands, talus slopes, and alluvial deposits. Chaining operations have reduced the extent of this type, but it is still one of the most common types.

Structure and Composition

The tree layer of this type is composed of varying amounts of pinyon pine, Utah juniper and rocky mountains juniper. Pinyon pine is found in almost pure stands on the broader ridges, while Utah juniper becomes the dominant species on steeply sloping sites. The canopy cover of all stands of this type, regardless of the species composition, is relatively low with a commensurate low density (approximately 150 to 250 trees per hectare).

It is suspected that competition for nutrients and water tends to restrict the growth of shrubby and herbaceous vegetation. The shrub and herb layers appear to be poorly developed and variable. As expected, big sagebrush usually occurs as the dominant shrub on the ridgetop stands. On the slopes, serviceberry, bitterbrush, and mountain mahogany become the dominant shrubs. These species are more characteristic of the mixed mountain shrub community, but demonstrate the interactions of topoedaphic effects on community structure and composition. Total shrub cover is expected to be five percent or less, but with a relatively high density (2000 to 3000 shrubs per hectare). Herbaceous cover is expected to average 15 percent ($\pm$5 percent), with western wheatgrass, needle-and-thread grass, Indian ricegrass, fleabane, (Erigeron spp.) sheep fescue, and Junegrass occurring as dominant or codominate species within the stands.

APPENDIX A

TABLE 1

PLANT SPECIES NOTED DURING SITE VISIT
(6/6/78 - 6/7/78)*

Trees and Shrubs

Amelanchier alnifolia
Artemisia tridentata
Atriplex confertifolia
Cercocarpus montanus
Chrysothamnus nauseosus
Chrysothamnus viscidiflorus
Juniperus osteosperma
Pinus edulis
Purshia tridentata
Ribes spp. (2)
Sarcobatus vermiculatus
Symphoricarpos oreophilus

Forbs and Half-Shrubs

Agoseris glauca
Antennaria parvifolia
Artemisia frigida
Astragalus spp. (2)
Astragalus spatulatus
Boraginaceae spp. (2)
Caryophyllaceae sp.
Castilleja sp.
Clematis ligusticifolia
Compositae spp. (3)
Cruciferae spp. (2)
Cryptantha sp.
Delphinium sp.
Eriogonum flavum
Eriogonum loncophyllum
Euphorbia robusta
Gilia aggregata
Gilia congesta
Linum perenne
Lupinus sp.
Machaeranthera grindelioides
Machaeranthera tanacetifolia
Mahonia repens
Mentzelia albicaulis
Oenothera caespitosa
Oenothera flava
Orobanche fasciculata
Penstemon spp. (2)
Penstemon nitidus
Phlox sp.
Phlox hoodii
Rosa sp.
Sisymbrium loeselii

Grasses and Grass-like Plants

Agropyron smithii
Agropyron spicatum
Carex filifolia
Phleum pratense
Poa sandbergii
Oryzopsis hymenoides

*Tentative identification - no voucher specimens collected.

Pinyon-juniper woodlands also occur on north facing slopes to a limited extent. Here, presumably because of more favorable moisture conditions, the understory is more dense, and again has the appearance of the mixed mountain shrub community, except for the overstory of trees. Shrub cover should approach 25 percent and the density would be at least ten times that of the ridgetops (20,000 to 30,000 shrubs per hectare). The herbaceous layer should approach 25 percent cover in these stands, with the dominant species being western wheatgrass, Junegrass, needle-and-thread grass, and perhaps fairy candelabra (Androsace septentrionalis).

Stability, Diversity, and Succession

The pinyon-juniper woodlands are one of the most stable plant communities in the entire region. These trees do not appear to be invading other communities, although saplings would be expected to occur intermittently in adjacent sagebrush areas. Diversity of the herbaceous component is considered to be of intermediate value when compared to the other plant communities.

Environment

The pinyon-juniper woodlands are developed mostly on soils that tend to be thin and have developed over fractured or non-fractured sandstone. Most of the precipitation falling on the woodlands would be expected to moisten the surface soil layers, evaporate, or sublimate (as in the case of snow). Runoff is expected to be minimal.

Fires may occasionally occur in the pinyon-juniper woodlands, but are probably not frequent because the open canopy and sparse understory do not provide enough fuel for frequent fires. In the case of a fire, regeneration of the woodland would be slow and opportunistic, being dependent on seed source, soil moisture and competition with other species.

(2) Chained Pinyon-Juniper Rangeland

The chained rangelands are somewhat of an artificial plant community and are highly variable. This community was produced though management practices and its distribution was determined by the selection of the chaining sites. The chaining sites are restricted to those areas where bulldozers can operate. Thus, for the most part, the chaining is restricted to ridges and gentle hillsides. Chaining was completed in 1969.

Structure and Composition

The general appearance of the chained rangeland is that of a shrubland with many fallen trees. Shrub cover is estimated to be approximately ten percent, and shrub density is estimated to be between 4000 and 5000

shrubs per hectare. The dominant species are big sagebrush, bitterbrush, and a few saplings of pinyon pine and Utah juniper. Snowberry may be locally abundant, usually on north facing slopes, and can reach dominant status in these locations.

Herbaceous cover appears to be approximately twice that of the pinyon-juniper woodlands (approximately 30 percent). Common perennial grasses are western wheatgrass, squirreltail grass, and Indian ricegrass. Annual species also occur, with cheatgrass being the most common, but including goosefoot, tansy mustard, and stickseed.

Stability, Diversity, and Succession

The chained rangelands are ecologically unstable communities. The chaining process has greatly altered the original woodlands and its associated species composition. The chained rangelands are presently undergoing successional changes which will continue until the woodlands become reestablished. The variability of these chained areas is a result of original differences in the woodland and also from different successional rates (greater successional rates where environmental factors are more favorable). It is estimated that it may take as long as 200 years for these chained sites to return to woodlands.

Environment

As expected, the soils in the chained rangelands have essentially the same characteristics as those in the pinyon-juniper woodlands.

The pattern of snow distribution has been altered as a result of the chaining operations, with snow tending to collect in the lee of the windrows of fallen trees, thus having an effect on the distribution of soil moisture.

Fires could occur within the chained areas, due to the abundance of fuel from the fallen timber.

(3) Big Sagebrush Communities

Throughout the Piceance Creek basin, big sagebrush communities are widely distributed and occur as two structurally different types. The upland sagebrush type occurs on ridges and clearings in the pinyon-juniper woodlands. Here the sagebrush is much smaller in stature and less dense than in the bottomland sage type. The bottomland sage type occurs on valley floors, alluvial fans, and draws. Here it occurs at high densities and sometimes attains heights of over three meters. The variation in size and density of these two sagebrush types results from different combinations of environmental parameters as well as possible sub-specific differences on the genetic level. Although both occur on loamy soils, nutrients such as potassium, phosphorus, and sulfate tend to occur at higher levels in the lowland areas than in upland areas. Additionally, soil texture and its effect on soil moisture could also

affect the size and density of the sagebrush. Similarly, total salts tend to be deficient in upland areas and excessive in the valleys.

Upland Sagebrush Communities

As mentioned previously, this community occurs on broad ridgetops and in clearings within the pinyon-juniper woodland, but usually is not found on sloping sites.

Structure and Composition

Big sagebrush is the dominant species in the upland sagebrush communities at estimated densities approaching 10,000 shrubs per hectare. Other species of shrubs are relatively unimportant. Pinyon pine and juniper saplings occur, but at low densities.

The herbaceous layer is composed of many species. Commonly, the following species are expected to occur: prickly pear (Opuntia polyacantha), western wheatgrass, Junegrass, long-leaved phlox (Phlox longifolia), false dandelion (Agoseris glauca), mariposa lily (Calochortus spp.), clover (Trifolium gymnocarpon, and Microsteris micrantha. Herbaceous cover can approach 45 percent in these stands. Mosses and lichens also occur, but only around the bases of individual sagebrush plants. This is due to an accumulation of litter plus snow and branch runoff which produce suitable habitat for mosses and lichens in these microsites.

Stability, Diversity, and Succession

The upland sagebrush community is an ecologically stable type. Two elements point to this conclusion. First, the diversity of the herbaceous cover is high which, although influenced by other factors, suggests that this community has been established for a considerable time period.

Secondly, the age-size distribution (young versus mature plants) suggests a self-sustaining community in equilibrium with local environmental conditions.

Thus, this sagebrush community is not successional. At higher elevations in the surrounding area, there is a greater component of mixed mountain shrubland species within the sagebrush communities.

Environment

The soil characteristics for this community type have been mentioned above.

Snow accumulation in this community is important as a source of soil moisture. It is estimated that during the winter, snow will accumulate to a depth approximately equal to the height of the sagebrush. During

the spring melt, the moisture accumulates in the loamy soils with very little runoff.

Fires can occur occasionally in this community, most likely within the clearings of the pinyon-juniper woodland, but probably not frequently enough to govern the distribution of this vegetation type.

Bottomland Sagebrush Communities

Throughout the Piceance Creek basin the bottomland sagebrush communities typically occur in the valley floors and alluvial fans of the gulches. Valleys which contain intermittent streams are usually dominated by this community. It also extends in narrow bands up the small draws and sometimes essentially reaches the top of the plateaus. The best examples of this community types can be seen along Horse Draw and its side gulches.

Structure and Composition

Big sagebrush is the dominant species with estimated cover being between 35 and 40 percent. Densities are estimated to approach 18,000 individuals per hectare, which is at least 1.5 times that of the upland sagebrush community. Other shrub species occur, such as rabbitbrush, but at low cover and density. Prickly pear and winter fat also occur, but again have low density and cover.

The herbaceous component in this community is considerably different from the upland sagebrush community. Usually these communities have as their dominant species cheatgrass, goosefoot, stickseed, and mountain peppergrass (Lepidium montanum), all of which are characteristic of disturbed sites. Western wheatgrass is the most common perennial species. It is expected that each of the above mentioned species would approach 50 to 100 percent frequency if sampled.

Stability, Diversity, and Succession

The widespread occurrence and homogeneity in addition to the age-size distribution suggest that this community type has played a long term role in the regional vegetation dynamics.

It appears, as discussed above, that high salt concentrations which are characteristic of this community inhibit the development of a diverse understory. Herbaceous diversity is expected to be approximately one-third that of the upland sagebrush communities.

The bottomland sagebrush community is not successional although agricultural disturbance will favor the development of rabbitbrush as opposed to big sagebrush.

Environment

The importance of the various soil factors and soil moisture have been previously discussed. Other environmental factors probably play a minor role in the distribution of this community type.

Although fire probably occurs periodically in this type, it does not play an important role, even though sagebrush is intolerant of fire.

(4) Bunchgrass Community

The bunchgrass communities principally occur on the steep talus slopes on the sides of the major gulches. They occupy positions intermediate between the pinyon-juniper woodlands and the bottomland sagebrush, agricultural meadows or greasewood communities. They may also occur on the burned pinyon-juniper woodlands. Although these burned areas are relatively level, other environmental parameters, such as solar radiation and soil moisture, make them more similar to talus slopes.

Structure and Composition

The shrub layer in this community type is poorly developed. The total density of shrubs may approach 2500 individuals per hectare depending on the particular stand sampled. At certain locations within the study area (e.g., along the lower portions of Horse Draw), shadscale (Atriplex confertifolia) and fourwing saltbush (Atriplex canescens) may occur within this community. This is probably due to the high salt concentrations in the soils within localized areas from the geochemistry of the underlying strata that outcrop on certain slopes.

The herbaceous cover in this community should approach 30 percent, with bare ground and rock approaching an additional 50 percent, and the remainder being accumulated litter. The dominant species in this community type is Indian ricegrass, which reaches its maximum development when compared to the other communities within the study area. Buckwheat (Eriogonum lonchophyllum), brickelbrush (Brickellia grandiflora), and cheatgrass are also common.

Stability, Diversity, and Succession

This bunchgrass community is ecologically stable on the talus slopes, and is unlikely to be replaced due to the extreme environmental conditions which are imposed and the concurrent adapted species that exist in these areas. Diversity is low compared to other communities.

The bunchgrass communities which develop in the burned pinyon-juniper areas are successional and will be eventually replaced by upland sage communities or pinyon-juniper woodlands.

Environment

Some of the most severe environmental conditions within the study area are found where most of the bunchgrass communities occur (steep talus slopes). These include increased penetration of solar radiation due to the cover, increased re-radiation of long wave radiation during the night, and poor water retention capacity of the soils present on these sites.

Fire does not play a significant role in those bunchgrass communities occurring on talus slopes, but Indian ricegrass responds favorably to burning, and where the pinyon-juniper woodlands have been burned, it sometimes assumes dominance in the early successional stages.

(5) Mixed Mountain Shrubland

Mixed mountain shrublands are widespread and abundant within the Piceance Creek Basin, and are composed of numerous shrub species which are important in supporting mule deer populations. The structure and composition of this community type vary considerably due the dominance of many shrub species in response to differing topoedaphic and soil moisture regimes encountered. The most typical stands of this community are composed of serviceberry (Amelanchier spp.), bitterbrush (Purshia tridentata), Gambel's oak (Quercus gambelii), snowberry (Symphoricarpos oreophilus), and mountain mahogany (Cercocarpus mountanus). On other sites big sagebrush may play a dominant or codominant role. Other species may occur to a lesser extent. These include: Gooseberry and currant (Ribes spp.), mountain lover (Pachystima myrsinites), Oregon grape (Mahonia repens), squaw apple (Peraphyllum ramosissimum), chockecherry, and skunkbrush (Rhus trilobata). Even though typical stands of this community contain many species, there are sites on which only a single species is dominant (e.g., Gambel's oak). Mountain mahogany sometimes occurs as a dominant on steep, relatively dry slopes. In other areas, big sagebrush and serviceberry are the community dominants. The most diverse stands of this community are usually located on steep, north facing slopes at lower elevations. This community type, however, is not restricted to steep slopes and occasionally occurs on ridgetops and south facing slopes. The species composition of any particular stand appears to be related to the topographic condition on which it occurs.

Structure and Composition

As mentioned above, this community is composed of many shrub species (serviceberry, mountain mahogany, Gambel's oak, snowberry, chokecherry and Oregon grape). There is stratification within the shrub layer; Gambel's oak, serviceberry and mountain mahogany primarily compose the canopy, while in other areas snowberry forms a nearly continuous understory.

The herbaceous layer is again varied and includes Watson's beardtongue, pasque flower, elk sedge, sugar bowls, and fairy candelabra. In addition, low growing shrubs such as Oregon grape and mountain lover are also common in this layer.

It is important to note that small patches of this community (composed of one or more species) occur at the heads of lateral gulches and intermittent stream channels. Even though such areas are small, they are important habitats for wildlife species.

Stability, Diversity, and Succession

These communities in their typical form are ecologically stable and unlikely to undergo successional processess, and as can be determined from the above discussion, are quite diverse.

Environment

Some of the most favorable conditions for plant growth within the study area exist in these communities because of the associated environmental characteristics. Soil conditions are favorable and have been modified as a result of soil-plant interactions. Snow tends to accumulate on these areas and, coupled with slow melting in the spring, allows good percolation. In addition, the north facing aspect of many of these sites results in retention of relatively high soil moisture content throughout the growing season. These factors collectively lead to increased production which in turn leads to higher soil organic matter.

Fire does not appear to be an important factor in these communities and their distribution.

(6) Greasewood Communities

This community is restricted to valley bottoms and alluvial fans which have high levels of salts, although isolated individuals may occur elsewhere.

Structure and Composition

The intensive grazing use and the associated trampling of this community type strongly affects the species composition.

The dominant shrub in this type is greasewood (Sarcobatus vermiculatus). Cover of this species is expected to range between 20 and 30 percent with densities approaching 6000 shrubs per hectare. The shrub canopy is not continuous, as the individuals tend to grow in clumps. Chrysothamnus nauseosus also occurs, but is far less abundant than greasewood.

The herbaceous layer contains few species, probably as a result of the high soil salt concentrations and disturbance. The total cover in this layer probably approaches 40 percent, most of which is attributed to the two dominant species, crested wheatgrass (Agropyron cristatum) and cheatgrass. It is presumed that the crested wheatgrass was seeded in these areas to improve the forage values.

Stability, Diversity, and Succession

This community type is considered to be ecologically stable. Few species can compete under the environmental conditions that exist within this community. Diversity is low, but the herbaceous species present can withstand heavy utilization and disturbance. No successional changes are expected to occur.

Environment

This greasewood community normally exists on loamy soils, with a relatively high pH, and contain excessive amounts of nitrates, sulfates, and sodium. The high salt levels are probably caused by storm runoff, which tends to percolate to a depth of four to six inches. As moisture evaporates from the surface, the salts are carried to the surface by capillary action, thus producing unsuitable germination and establishment conditions for many plant species. Greasewood is a phreatophyte, which means its roots extend down to the fringe of the capillary water supply of the ground water table. Thus, by being tolerant of salty soils, it is also assured of a continuous water supply.

Other environmental factors are less important. The species that compose the greasewood community are intolerant of fire, so that considerable damage is incurred if fires occur.

(7) Annual Weeds

This is a somwehat artificial community which developes on disturbed sites such as around ranch yards, stock pens, industrial development sites (drilling facilities, access roads, etc.). As expected, there is no pattern to the location of this community, and the vegetation varies between sites.

Structure and Composition

Shrubs are usually lacking from these disturbed sites, although an occasional individual may be found. The herbaceous layer contains many species of annual weeds. In some areas perennial grasses are present, most commonly western wheatgrass and Indian ricegrass. The annual species which dominate different sites include cheatgrass, tumble mustard (Sisymbrium altissimum), Russian thistle (Salsola kali), goosefoot (Chenopodium albium) and white pigweed (Amaranthus albidus).

Stability, Diversity, and Succession

This community represents the first stage of succession that developes on disturbed sites and is therefore ecologically unstable. The final or climax vegetation that will become established is dependent on the surrounding vegetation and the type of soils. Hence, upland areas may eventually become pinyon-juniper woodlands or upland big sagebrush communities. Valley sites are more likely to support big sagebrush communities. Re-esablishment of shrub communities may take 60 to 70 years, while woodland communities may take as long as 200 years.

Diversity is low in comparison to other communities.

Environment

In this community type, environmental conditions are not conducive to plant growth. Soil characteristics have been changed, coarse material may have been brought to the surface, the soil may have become severly compacted, and soil organic matter is low, but will increase as succession continues.

(8) Agricultural Meadows

The agricultural meadows within the study area are restricted to the floodplains along the major streams, in particular, Piceance Creek. They are composed of alfalfa and introduced pasture grasses. No successional changes are expected as long as current management is maintained.

(9) Great Basin Wild Rye Communities

Formerly, this community occupied large areas of floodplains. However, since the time when agricultural practices began in the area, only small remnants of the original vegetation patterns can be found, for example, further upstream along Piceance Creek about four miles west of the Rio Blanco store.

Structure and Composition

The dominant species in this community is Great Basin wild rye (Elymus cinereus), which grows as large tall clumps (up to 2.5 meters). It is non-rhizomatous and therefore does not form a continuous cover, but the cover is very dense within these clumps. Big sagebrush is sometimes seen within these areas, but is not common.

The herbaceous component includes cheatgrass and mountain peppergrass.

Stability, Diversity, and Succession

This community is ecologically stable, diversity is low, and no successional changes are expected if left undisturbed. It appears that this was the climax community on the floodplain areas.

Environment

This community occurs on loamy alluvial soils. These soils may be saline due to large amounts of sulfate and sodium. If salt levels had been considerably higher, then it is likely that greasewood communities would have developed.

(10) Marshlands

The marshlands occur only along Piceance Creek and stock ponds where the water is shallow and constant. These areas are uncommon.

Structure and Composition

The marshlands are composed of perennial herbaceous aquatic and semi-aquatic plants. Some areas contain a few willows (Salix spp.), but these are small and inconspicuous. The dominant species are cattail (Typha latifolia), common reed (Phragmites australis), and numerous species of rushes (Juncus spp.) and sedges (Carex spp).

Stability, Diversity, and Succession

As long as the present environmental conditions remain unchanged, these are stable communities. If the sites were to dry out, they would be replaced by a more mesic type community such as a sedge meadow. If new wet areas were established they would rapidly become marshlands.

Environment

The existing environmental conditions are considerably different from the surrounding areas because of the standing water: this would include precipitation, atmospheric moisture, and wind. The soils are always saturated, and the soil organic matter concentration is quite high due to the unutilized production.

(11) Riparian Communities

Within the study area the best developed riparian communities are along Piceance Creek.

Structure and Composition

Willows occur to a limited extent, but again, most individuals are small and isolated. The majority of the vegetation is composed of rushes, sedges, horsetails (Equisetum spp.) and grasses (Beckmannia syzigachne, Agrostis alba, and Phleum pratense). Other species along the stream include checker mallow (Sidalcea neomexicana), Nuttall's sunflower (Helianthus nuttallii), Canada goldenrod (Solidago canadensis), nettle (Urtica dioica) and marsh elder (Iva xanthifolia). The above species are restricted mostly to the stream trenches: they also occur on the sloping banks. The community along Piceance creek is bordered by agricultural meadows, but the separation is sometimes indistinct, as many semi-aquatic species will occur in moist meadows. In other areas, the community is restricted to a narrow band immediately adjacent to the stream.

Stability, Diversity, and Succession

This is an ecologically stable community maintained by the streamflow. It recovers quickly from alterations due to irrigation ditches because of the favorable moisture conditions. Its extent has been increased because of irrigation canals and ditches which provide similar environmental conditions. Diversity is moderate to high.

Environment

Favorable conditions for plant growth exist along the stream, although in some cases soil moisture contents are excessive for certain species, thereby lowering the diversity. Soil nutrients are plentiful and augmented by enriched irrigation return flows.

(12) Aquatic Communities

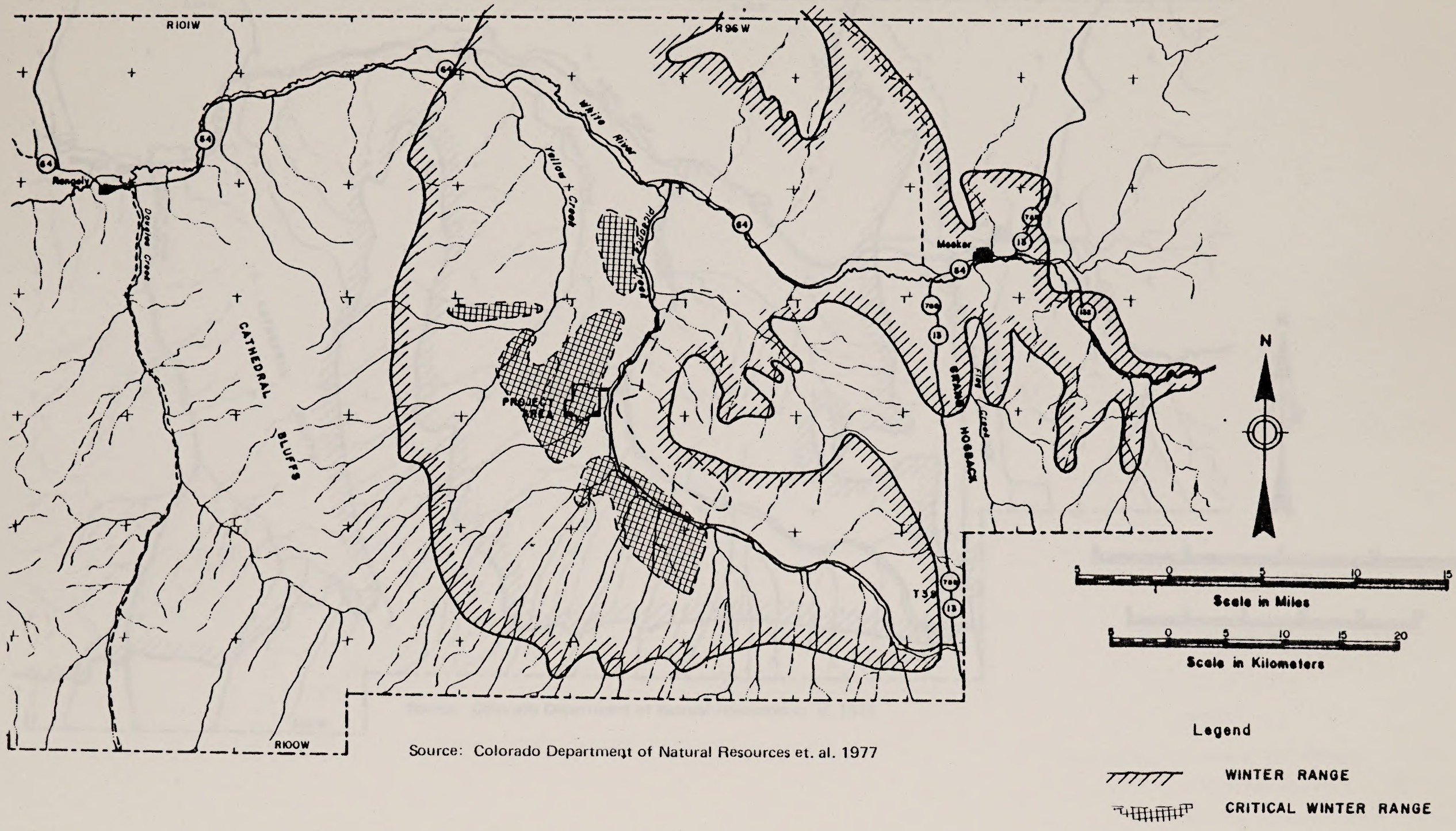
There is one known good spring and one pond (Ryan pond) located in Section 32, T1S, R97W.

Lotic communities

Ryan pond is the only known pond at this time within the study area. Organic matter is high and the bottom is probably covered with a fine sedimentary ooze. Pondweeds (Potomogeton spp.) are found in most ponds. Succession does not occur rapidly because the ponds are maintained by ranchers.

Lentic communities

Springs, seeps, streams, and rivers are all lentic communities. Piceance Creek supports local concentrations of watercress (Rorippa spp.). Springs may support such species, depending on the flow. Algae and related forms of plants are common in lentic communities.



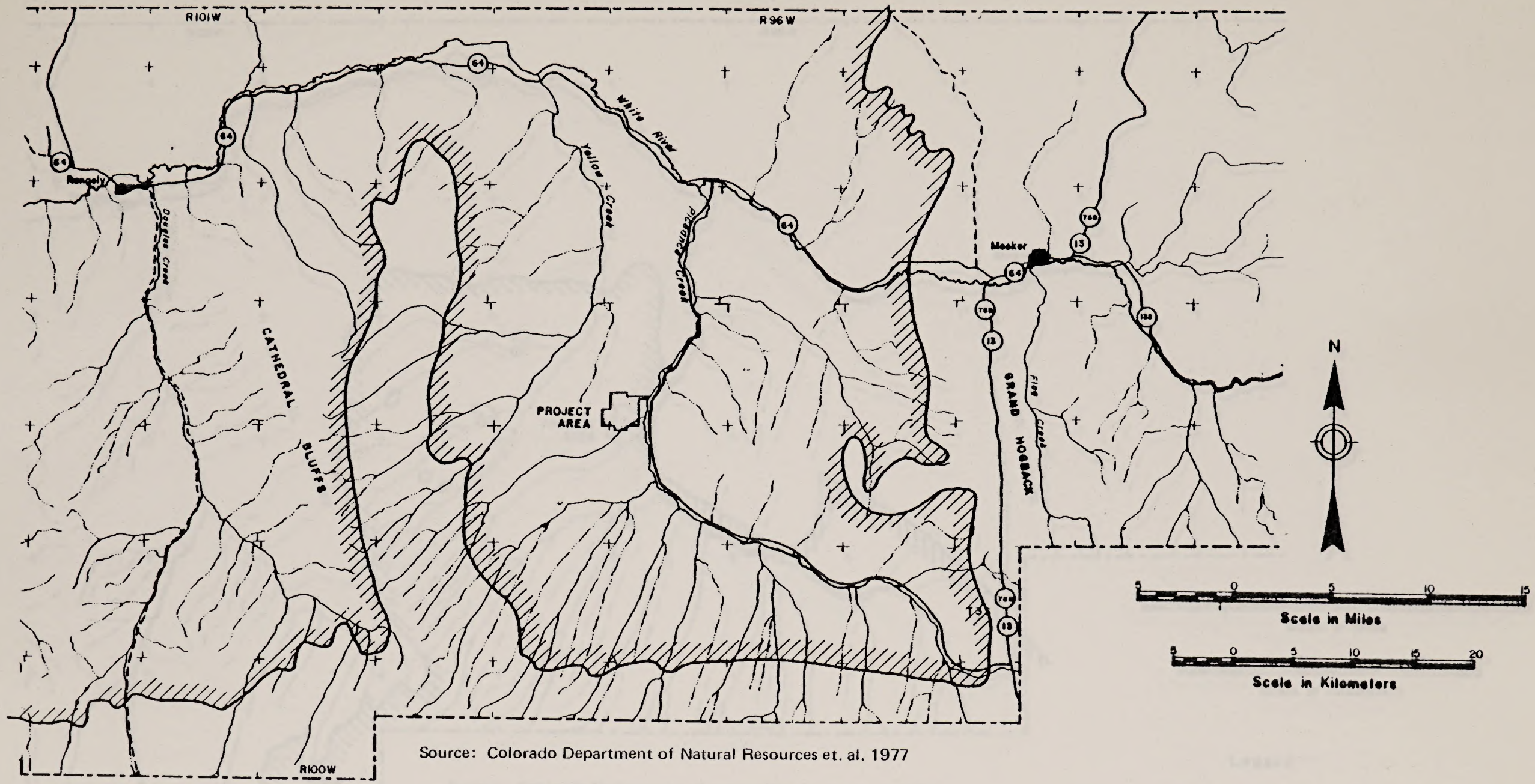
Source: Colorado Department of Natural Resources et. al. 1977

MULE DEER WINTER RANGE

APPENDIX A

FIGURE 1





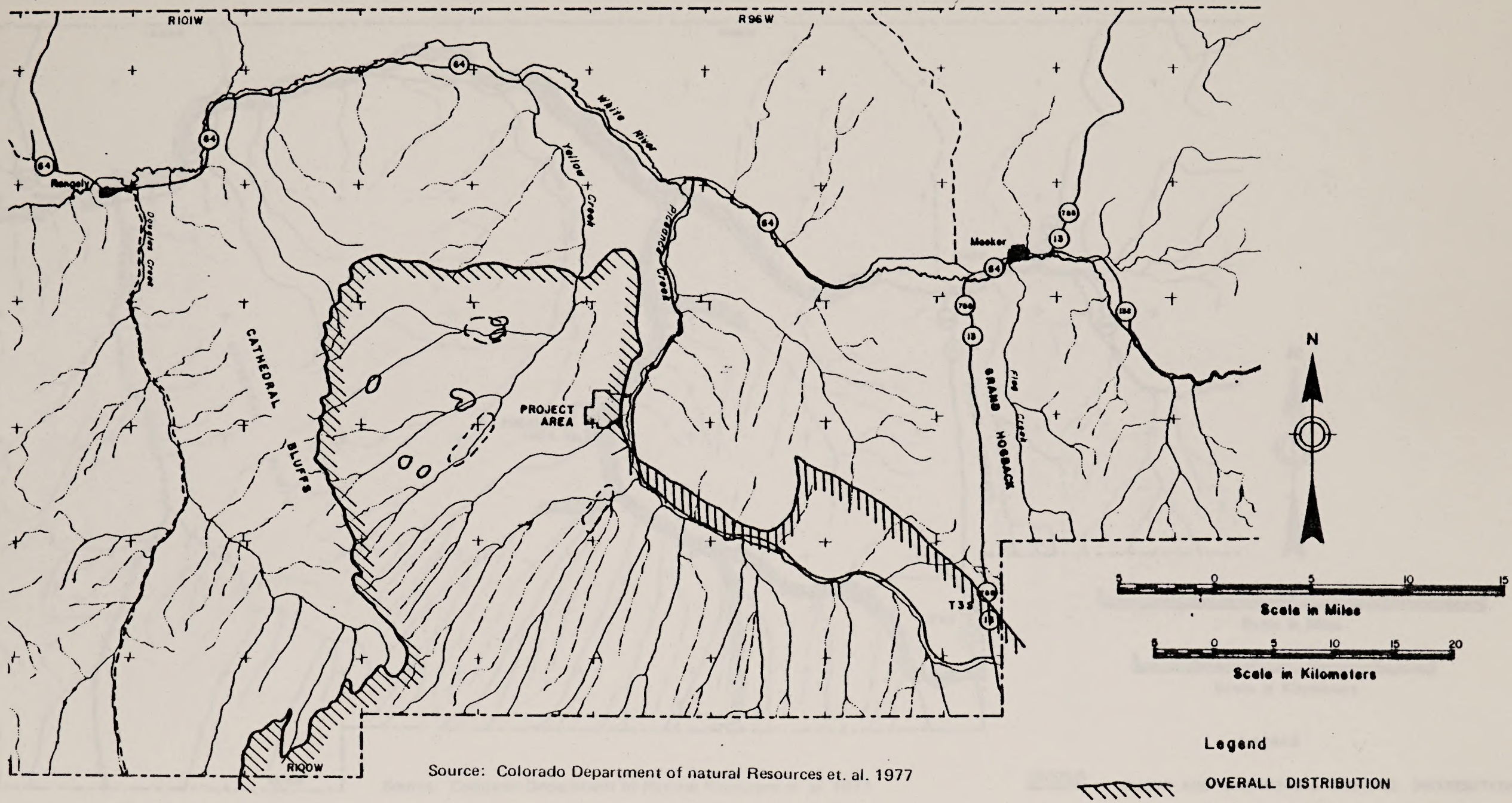
Source: Colorado Department of Natural Resources et. al. 1977

MOUNTAIN LION WINTER RANGE

APPENDIX A

FIGURE 2





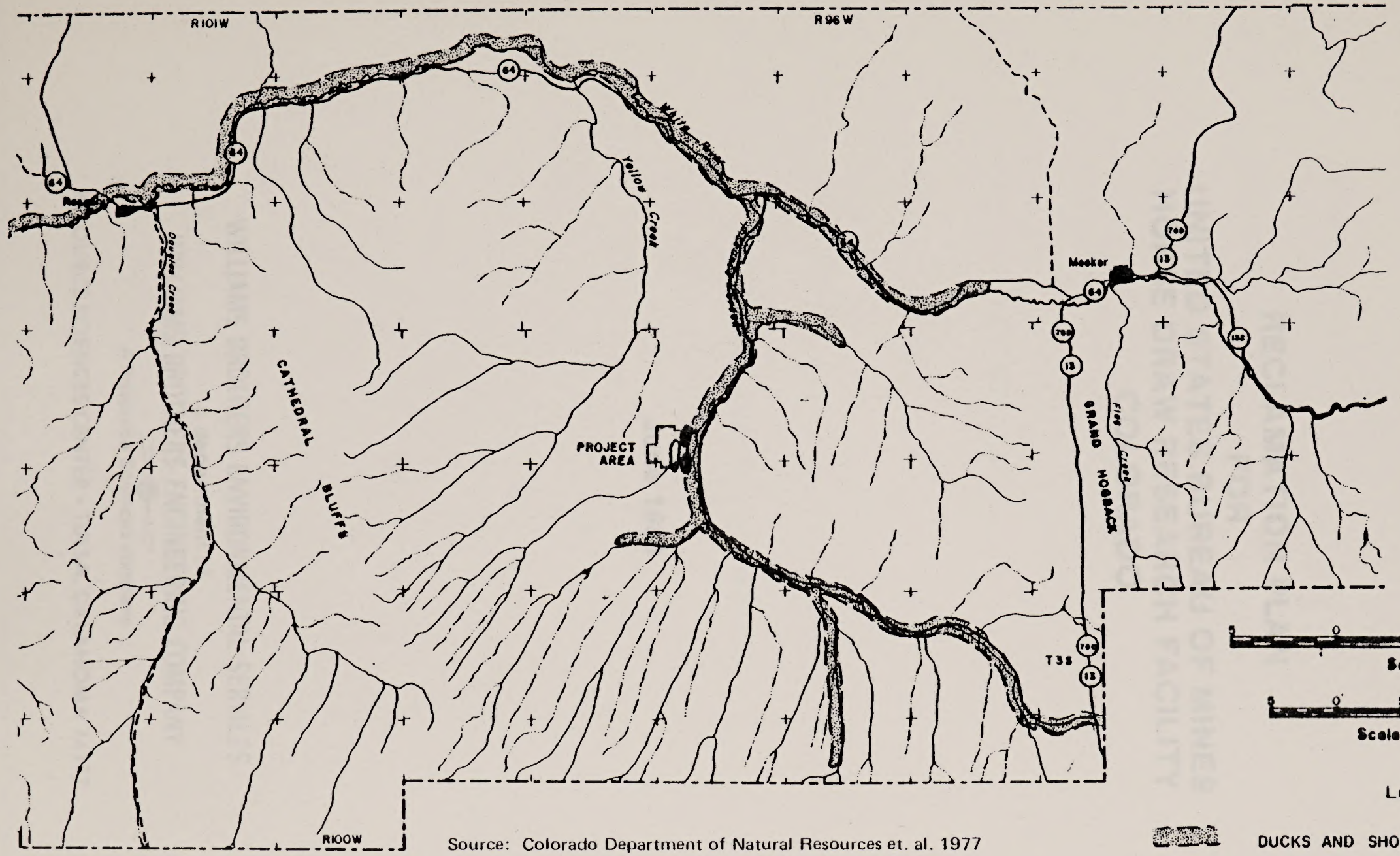
Source: Colorado Department of natural Resources et. al. 1977

SAGE GROUSE HABITAT

APPENDIX A

FIGURE 3





Source: Colorado Department of Natural Resources et. al. 1977

DUCKS AND SHOREBIRDS HABITAT

APPENDIX A
FIGURE 4



RECLAMATION PLAN
FOR
UNITED STATES BUREAU OF MINES
HORSE DRAW RESEARCH FACILITY
COLORADO

June 1980

WILLIAMS BROTHERS ENVIRONMENTAL SERVICES
a department of
WILLIAMS BROTHERS ENGINEERING COMPANY
A Resource Sciences company
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RECLAMATION PLAN
HORSE DRAW RESEARCH FACILITY

1.0 INTRODUCTION

The Bureau of Mines Horse Draw Research Facility consists of 22 acres in the SW¼ of Section 29, Township 1 South, Range 97 West, within the north central portion of Piceance Basin. Upon abandonment, lands disturbed by development of oil shale and other resources will be restored by methods consistent with good ecological and land use practices. To accomplish these goals, a revegetation plan has been developed that will:

1. Enhance natural succession and ecosystem recovery;
2. Establish sound erosion control and stabilization practices; and,
3. Provide adequate cover, forage and habitat for re-establishment of animal populations on the site.

It is proposed that the land be returned to its former use, that of rangeland and wildlife habitat. Since raw and processed shale is not a problem (it will be returned to the mine), only reclamation of the site itself will be addressed in this plan.

Major sites requiring revegetation of disturbed soils include the mine and plant site and support facilities. This area totals 22 acres. Revegetation of these sites will follow conventional techniques. Techniques used will be evaluated

to determine their suitability in establishing vegetation for support of existing animal populations. Aesthetics will also be considered.

This plan addresses methods and strategies selected to meet the criteria stated above. Revegetation activities fall into two categories: 1) planning and design; and 2) implementation. The planning and design category includes formulation of planting techniques, development of methods for evaluation of site success, and integration of pertinent information into initial plans and later program modifications. The implementation category includes site preparation, planting, maintenance, and evaluation of site success.

Rangeland and wildlife habitat is the proposed post mining land use since the Piceance Basin sustains the largest migrating mule deer herd in the nation. In line with BLM's multiple use goal, the resulting rangeland would be useful for wildlife habitat and livestock production. The majority of the surrounding land is presently used for rangeland by the BLM. Smaller areas along Piceance Creek are used for agriculture, primarily hay production by cattle ranchers.

Alternate vegetation plans for the site would establish a Pinyon-Juniper ecosystem using transplants. This plan is considered impractical because there is limited use of Pinyon and Juniper and a high probability for success in rangeland reclamation.

Numerous studies have shown that semi-arid foothills have moderate to high probability for revegetation success. Examples for the foothill zone of the Rocky Mountains with 12-14 inches of precipitation are indicated in the following quotes:

1. "Past history of rangeland seeding has shown that satisfactory revegetation can be accomplished if the best methods are practiced." (National Academy of Sciences, Rehabilitation Potential of Western Coal Lands, 1974).

2. "Average annual precipitation usually should be more than 9 inches where artificial seeding is part of the restoration program." (Plummer, A.P., Restoring Big Game Range in Utah).

With natural precipitation, there are good local examples of successful revegetation, particularly those programs instituted by Federal Oil Shale Lease C-b.

1. A disturbed surface soil plot was seeded in the Fall of 1972 and 1973 on the western boundary of Tract C-b by researchers from C.S.U. and funded by Colorado Department of Natural Resources. This planting indicates many suitable species for a revegetation program. (Information from E. B. Baker, Occidental Oil Shale, Inc.).

2. Evaluation for success of the 1975 revegetation efforts on drill pads and soil test trenches in and around the disposal and proposed disturbed areas for Federal Oil Shale Lease C-b has been good to excellent. (Information from E. B. Baker, Occidental Oil Shale, Inc.)

All reclamation shall be completed within five (5) years from the date that the Mined Land Reclamation Board has been

notified that reclamation is to be started. The reclamation plan will be initiated the first Fall following final disturbance of the area.

2.0 GRADING

Grading of the existing site is required in order to return the surface topography to approximate original contours. Drawing number C-1001-D shows premining topography and cross sections of the 22 acre site. Slope surveys along cross section lines revealed slopes ranging from 0 percent to 26 percent (Ab-Ac and Cc-Cd). Cross sections D-D and E-E are shown for the areas used for staging and stockpiling, respectively. Premining slopes in these areas range from 4 percent (Eb-Ec) to 17 percent (Ed-Ee) with the average slope being 10 percent (Da-Db).

Initial site modifications for mining activities required extensive grading. The site was altered so as to provide two large, level areas for staging and stockpiling (See drawing number C-1002-D). The stockpile area, to the east, is approximately 3 acres, and the staging area, on the west, including the lined mud pit, is approximately 6 acres. Slope surveys show cut slopes in excess of 50 percent (Da-Db and Ea-Eb) and fill slopes of 25 percent (Ec-Ed) and 33 percent (Cc-Cd). Slope Ca-Cb has increased from the original 25 percent to 27 percent through leveling activities in the stockpile area, and slope Cc-Cd has increased from 26 percent to more than 30 percent. Grading of the staging area has increased slope Aa-Ab and Ac-Ad from 12.5 percent to 16.6 percent and 25 percent, respectively.

Stability of reclaimed slopes is insured by recontouring, decreasing slope gradients, and compacting. Prior to placing fill in cut areas, the surface shall be ripped along the contours. Ripping disrupts the interface and ensures slope stability. Ripping will be at least to the full depth of the Caterpillar rippers. Leaching of raw and processed shale is not anticipated to be a problem because the shale will be returned to the mine. Mining mud or muck is used in small quantities and is not considered a disposal problem. It will be stored in the mud pit and mixed with the "surface" soil when the mud pit is ripped and the area recontoured. Affected areas will eventually be returned to approximate original contours (AOC) except where original contours preclude successful reclamation. Drawing number C-1003-D shows the proposed reclaimed surface elevations and cross sections. Table 1 presents a comparison of the existing contours to both premining and reclaimed contours.

Table 1 CONTOUR COMPARISON CHART.

Slope	Existing Contours	Premining (Original) Contours	Reclaimed (A.O.C.) Contours
Aa-Ab	16.6%	12.5%	10%
Ac-Ad	25%	12.5%	13.6%
Ba-Bb	Leveled off for mud	20%	6.25%
Bc-Bd	Pit & staging area	11%	8%
Ca-Cb	27%	25%	12.3%
Cb-Cc	33.3%	26%	11.6%
Da-Db	51.4% cut slope	10%	10%
Ea-Eb	50% cut slope	15%	16%
Eb-Ec	Leveled off for stockpile area	4%	3.5%
Ec-Ed	25% fill slope	17.1%	17%

All slopes over 11% reclaimed gradient should contain at least one waterbar (1 foot high x 1 foot wide at the base) at the midslope (along the contour) position to ensure slope.

Permanent surfaces of the cuts for the access road provide excellent erosion resistant material. Likewise, fills will be composed primarily of material used on the site and coarse broken rock. Erosion of slopes is expected to be minor.

3.0 WATER

Operators of the Research Facility will be in compliance with applicable Colorado water laws governing existing water rights, and applicable Federal and Colorado water quality laws and regulations. Since precipitation on the site does not replenish groundwater systems, surface water is the main concern in relation to reclamation work on affected areas. However, it is believed that rainfall will be adequate for the reclamation program, and there are no plans to provide supplementary irrigation in the reclamation plan.

Control of runoff from affected areas will be accomplished through prompt stabilization of these areas with either rock or vegetation. Larger rocks will be placed along the bottoms of gullies and gulches. These rocks, which act as energy dissipaters, will slow the movement of water through these areas, thereby increasing infiltration rates and reducing soil erosion.

4.0 WILDLIFE

Access road and surface facilities were already constructed at the time this reclamation plan was written. Therefore, preventive measures and modifications that would minimize impacts on wildlife during the construction period cannot be addressed; rather, impacts associated with reclamation

programs during operation and abandonment phases will be discussed.

Estimated effects of future actions on wildlife would be small when considering mining research programs. The entire twenty-two (22) acres with exception of a gulch that bisects the property has been drastically modified and little original topsoil or vegetation can be found. Operation of the facilities coupled with the presence of personnel has probably caused deer and other wildlife to utilize other areas.

The Facility is within a winter concentration area and is important deer habitat. A plan prepared for a Bureau of Mines large scale proposed project reported that disturbance of 260 acres would result in a loss of approximately twenty (20) animal units of forage. Thus, disturbance of twenty-two (22) acres is expected to result in a loss of approximately two (2) animal units of forage. Most forage production occurs on chained areas near the site and in the riparian area of Piceance Creek where no mining associated surface disturbance has occurred. Therefore, forage production for grazing is insignificantly affected.

The mud pit poses a potential hazard. Wildlife and livestock may be affected by drinking caustic water from the mud pit and by wandering into the pit and becoming immobilized. There is also a remote possiblity that migrating waterfowl might attempt to land in the mudpit and be adversely affected by the saline water; if so, a series of wires or cables will be strung across the pit to prevent birds from landing. Upon abandonment of the site, the lined mud pit will be ripped. This allows leachables to percolate down through the liner and not out the interface of the reclaimed "fill"

and original "cut" surface. The mud pit will be buried and approximate original contours returned.

The Research Facility is bounded by a three-strand barbed wire fence with metal posts that is used to keep livestock from using the site as a grazing area. The fence could impede deer movement through Horse Draw. Additional deer fencing will be added during implementation of reclamation plans and for a period of four (4) years thereafter to assure stabilization of the site.

The main impact on deer populations will be road kills by vehicles using Piceance Creek Road and the access road to the site. Road kills can reasonably be expected to be greatest during spring migration (March through May) and autumn migration (October through November) and would most likely occur in evening and morning hours. Movement of haul trucks and heavy equipment will be scheduled to reduce impacts on the deer herd. Carpooling and other transportation programs will be encouraged to reduce the number of vehicles using the roads.

The effect of habitat loss on mammals and reptiles is severe for those that lived in the disturbed areas, but marginal overall. Avian populations have been disturbed and some displaced. Raptor aeries and principal nest sites are not known to exist close to the mine facility area. The small percentage of habitat to be disturbed relative to the total extent of similar habitats in the region suggests that local reductions in mammal, reptile and bird numbers should not have significant consequences.

5.0 HABITAT RESTORATION

The Reclamation Plan includes contouring and revegetation of the graded and leveled areas. This plan addresses types of vegetation required to create a heterogenous vegetative cover on re-contoured and graded areas. Different vegetative types will maximize vegetative production and edge effect.

Grassland-saltbrush type vegetation, consisting of adapted native and introduced species, are planned for the South and West slopes. In this way early green forage, heavily used by deer, will be provided.

The more desirable shrubs such as bitterbrush and mountain mahogany will be used on the rest of the site. These shrubs provide good quality feed for summer and winter.

Pinyon, juniper and other native tree species locally present will be planted over the disturbed area. Their distribution patterns and density will conform as much as possible to that of the adjacent undisturbed area.

6.0 PUBLIC ACCESS

Access to the public shall be limited. All surface production facilities will be fenced. Where machinery is operating for stockpiling and loading, access will be restricted. No vehicle traffic will be allowed where revegetation programs are underway. Personnel will have to comply with state and federal wildlife regulations. Harassment of wildlife, excessive land disturbance, or actions which detrimentally effect the environment will be analyzed and mitigative measures instituted.

7.0 TOPSOILING

Little topsoil or topsoil-like material existed prior to clearing of the land. Available topsoil was not stockpiled. The entire disturbed area is composed of shale and sand. Initial treatment with sewage sludge or other organic material will be used to build up organic content of the soil and provide a more compatible environment for plant growth. Any dead slash and brush remaining from the initial clearing operation will be returned to provide habitat enhancement for small mammals and reptiles. This also serves as additional organic matter for the area. Appropriate seed will be planted in the first year for temporary stabilization. The following Fall, species planted will emphasize native varieties (See Table 2 for a list of selected species).

Potassium is generally deficient in the Piceance Basin (100 ppm), possibly because pH value is in excess of 7.0. Also, there are high lime percentages that inhibit phosphorus availability (26 ppm). Phosphorus, potassium, nitrogen, copper, zinc, iron and manganese are low. Therefore, the fertilization rate will be 80-100-50 (N-P-K) with a trace of Zn, Cu, Mn, Fe, or N-80 lbs/acre, P-100 lbs/acre, K-50 lbs/acre with trace elements. Fertilizers will be applied in the Fall after the first growing season with standard farm fertilizer broadcast spreaders. Dr. C. Wayne Cook, speaking at the Northwest Colorado Land Reclamation Seminar at Steamboat Springs, Co., in September, 1978 indicated that relatively low amounts of fertilizer applied in the early stages of reclamation has been successful in areas of low rainfall. Dr. Cook said that amounts as low as 20 lbs. of fertilizer/acre may be indicated where precipitation is less than 24" per year (Cook, 1978). When soil analysis has

been done, the lower amounts of fertilizer may be indicated for the second growing season. Fertilizer application is planned in the Fall after the first growing season so weed competition is not encouraged since weeds are generally most competitive the first year. (E. B. Baker, Occidental Oil Shale, Inc.).

8.0 REVEGETATION AND STABILIZATION

The goal of revegetation of disturbed or affected areas is to establish a diverse, effective, and long-lasting vegetation cover that is capable of self-regeneration without continued dependence on irrigation, soil amendments or fertilizers, and provide vegetation that is at least equal in extent in cover and productivity to the existing vegetation of the surrounding area.

Timing - Once a mining or operational activity has been completed, a specific revegetation plan will be carried out as promptly as possible. In most cases, timing of seeding is critical; if limited delays should occur, temporary stabilization will be used to minimize impacts while waiting for appropriate planting seasons. Revegetation will occur within one year of completion of an activity and generally much sooner. Plans will be made to try to time recontouring activities to the last part of spring and a suitable temporary crop such as spring wheat will be planted to provide stability to the area for the native seed which would be seeded late in the growing season.

Techniques and Materials - The site will be restored to rangeland and wildlife habitat. Seeding will be carried

out by drilling with a Rangeland drill. Areas which have too much rock will be broadcast seeded with twice the drilled rate, and walked in with a dozer. The best time for planting in the Piceance Creek Basin is late in the growing season, past the period for seed germination. This enables the seedlings to become established early in the next growing season when soil moisture is at optimum. If needed, Spring wheat will be planted in May or June to stabilize the area. All other seedings will be done in September to November. Transplanting will be done in April to June.

Seed that is drilled will be monitored because of the importance of depth of planting. The seed will be compacted lightly with a packer unit on the drill. In the case of broadcast seedings, a dozer will walk over the area to increase germination and establishment.

Straw (at approximately two [2] tons per acre), jute or other stabilizing and mulching materials will be "crimped in". This also serves to reduce wind damage and retain available moisture.

A list of applicable species and seeding rates of those species to be used on the project is included in Table 2.

TABLE 2- SPECIES LIST FOR BUREAU OF MINES RESEARCH FACILITY SITE RECLAMATION

	Species		Lbs/Acre Drilled P.L.S. = Pure Live Seed
Grasses:	Agrophyron cristatum	- crested wheatgrass	3
	A. elongatum	- tall wheatgrass	2
	A. smithii(rosana)	- western wheatgrass	4
	A. intermedium(amur)	- intermediate wheatgrass	2
	Elymus cinereus	- Great Basin wildrye	1
	E. junceus	- Russian wildrye	1
Forbs:	Hedysarum boreale(Utah)	- Utah sweetvetch	1/2
	Medicago sativa	- Alfalfa	1
Shrubs:	Atriplex canescens	- four wing saltbrush	2
	A. confertifolia	- shadscale	1
	Eurotia lanata	- winterfat	1
Trees:	Juniperus osteosperma	- Utah juniper	Transplants
	Pinus edulis	- pinyon pine	Transplants

APPENDIX B

AIR QUALITY

APPENDIX B

AIR QUALITY

A. Fugitive Dust Emissions

1. Ore handling from stockpile to crusher

a) Loading ore into a front-end loader

Source: USEPA Region VIII Policy Paper dated December 10, 1979

Emission Factor: 0.12 #/T

Assumption: 14,000 tons of ore will be loaded into the front-end loader

Calculations:

(0.12 #/T) (14,000 T)
= 1,680 #
= 0.84 tons

Tons = 0.84

b) Dumping ore into the crusher

Source: USEPA Region VIII Policy Paper dated December 10, 1979

Emission factor: 0.007 #/T

Assumption: 14,000 tons of ore will be dumped

Calculations:

(0.007 #/T) (14,000 T)
= 98 #
= 0.05 tons

Tons = 0.05

Total = (a) + (b) = 0.89

2. Ore handling from crusher to the shaft

a) Dumping crushed ore into the shaft

Source: USEPA Region VIII Policy Paper dated December 10, 1979

Emission Factor: 0.007 #/T

Assumptions: 14,000 tons ore will be dumped into the shaft

Calculations:

(0.007 #/T) (14,000 T)
= 1,680 #
= 0.84 tons

Tons = 0.84

3. Traffic on unpaved road (haul roads)

Source: USEPA Region VIII Policy Paper dated December 10, 1979

Emission Factor:

$$E = \frac{\text{\# emission}}{\text{vehicle mile}} = (2.5)\ (0.6)\ \left(0.81\ \frac{\#}{\text{vehicle-mile}}\right)$$

$$(s)\ \frac{(V}{30}\ \frac{(365-W)}{365}$$

where

2.5 is the factor used for off-highway heavy duty mining trucks

0.6 = the fraction of release that remains suspended

s = silt content of the road in percent

V = average vehicle speed in mph

W = mean annual number of days with 0.01 inches or more of rain

Assumptions:

(a) 14,000 tons/yr of ore will be removed

(b) density of ore 1.86 ton/yd^3

(c) total cubic yard = 7,527/yr

(d) one front-end loader with 3-yd^3 capacity

(e) round trip distance from the crusher to the shaft = 0.3 miles

(f) average speed of front-end loader = 2 mph

(g) silt content of unpaved road = 25%

(h) the average number of days with 0.01 inch or more of rain is 182

Calculations:

Total cubic yard = 7,527/yr

Total number of trips by front-end loader = $\frac{7,527}{3}$ = 2,509/yr

Total vehicle miles travelled/yr = (2,509) (0.3)

= 752.7

$$E = (2.5)\ (0.6)\ (0.81)\ (25)\ \left(\frac{2}{30}\right)\ \left(\frac{365-182}{365}\right)\ (752.7)$$

= 761.8 #

= 0.38 tons

<u>Tons = 0.38</u>

4. Traffic on unpaved access roads

Source: USEPA Region VIII Policy Paper dated December 10, 1979

Emission factor:

$$E = \frac{\#\ \text{emission}}{\text{vehicle-mile}}$$

$$= (0.60)\ (0.81\ \frac{\#}{\text{vehicle-mile}})\ (s)\ (\frac{V}{30})\ (\frac{365-W}{365})$$

where

0.6 = the fraction of release that remains suspended

s = silt content of the road in percent

V = average vehicle speed in mph

W = mean annual number of days with >0.01 inches of rain

Assumptions:

(a) an average of 30 workers will use USBM facility, every worker will drive an automobile to work 365 days/year

(b) the gravel access road to the site is 1.55 miles long, therefore round trip distance = 3.10 miles

(c) silt content of gravelled road = 15%

(d) average speed, 25 mph

(e) average number of days with 0.01 inch or more rain is about 182

Calculations:

$$\frac{\text{vehicle miles travelled}}{\text{yr}}$$

$$= (\frac{30\ \text{autos}}{\text{day}})\ (\frac{3.10\ \text{miles}}{\text{auto}})\ (\frac{365\ \text{days}}{\text{yr}})$$

$$= 33{,}945/\text{yr}$$

$$E = (0.60)\ (0.81)\ (15)\ \left(\frac{25}{30}\right)\ \left(\frac{365-182}{365}\right)\ (33{,}945)$$

$$= 102{,}200\ \#$$

$$= 51.1\ \text{tons}$$

Tons = 51.1

5. Transportation of oil on unpaved road

Source: USEPA Region VIII Policy Paper dated December 10, 1979

Emission factor:

$$E = \frac{\#\ \text{emission}}{\text{vehicle-mile}}$$

$$= (2.5)\ (0.6)\ \left(0.81\ \frac{\#}{\text{vehicle-mile}}\right)\ (s)\ \left(\frac{V}{30}\right)\ \left(\frac{365-W}{365}\right)$$

where

2.5 is the factor used for off-highway heavy duty mining trucks

0.6 = the fraction of release that remains suspended

s = silt content of road in percent

V = average vehicle speed in mph

W = mean annual number of days with >.01 inches of rain

Assumptions:

(a) 480,000 refined oil production for 20-day period

(b) 6,000 gal. truck operating every six hours for 20 days

(c) distance to unpaved road, one-way, is 1.6 miles, therefore, round trip = 3.2 miles

(d) average speed of the truck, 10 mph

(e) silt content of unpaved road is 25%

(f) the average number of days with 0.01 inch or more of rain is 182

Calculations:

Vehicle Miles Travelled (VMT)

$$= \left(\frac{3.2 \text{ miles}}{\text{trip}}\right)\left(\frac{4 \text{ trips}}{\text{day}}\right)\left(\frac{20 \text{ days}}{\text{yr}}\right)$$

$$= 256 \text{ miles/yr}$$

$$E = (2.5)\ (0.6)\ (0.81)\ (25)\ \left(\frac{10}{30}\right)\ \left(\frac{365-182}{365}\right)\ (256)$$

$$= 1{,}296\ \#$$

$$= 0.648 \text{ tons}$$

Tons = 0.648

B. Point Source Emissions

1. Emissions from Boiler

Source: AP-42, Compilation of Air Pollutant Emission Factors

Emission factor:

	$lb/10^3$ gal.
Particulate	2
Sulfur dioxide	142s
Sulfur trioxide	2s
Carbon monoxide	5
Hydrocarbons	1
Nitrogen oxides	22

Where: s is the percent of sulfur in fuel oil

Assumptions:

(a) boiler rated at 1,000 #/hr

(b) boiler uses distillate #2 fuel oil

(c) sulfur content of fuel oil, 0.3%

(d) BTU/# of fuel oil = 18,500

(e) fuel oil density = 7.5 #/gal.

Calculations:

1,000 #/hr at 1,000 BTU/#

$= 10^6$ BTU/hr

Distillate fuel oil = 138,750 BTU/gal

$$\text{Therefore, gal/hr} = \frac{1{,}000{,}000 \text{ BTU/hr}}{138{,}750 \text{ BTU/gal}}$$

$$= 7.21 \text{ gal/hr}$$

Boiler operating for 480 hours

(7.21 gal/hr) (480 hrs)

= 3,461 gal

	lb/10^3 gal	For 3,461 gal	
		lbs	tons
Particulate	2	6.92	0.003
Sulfur dioxide	142s	147.4	0.07
Sulfur trioxide	2s	2.1	<0.001
Carbon monoxide	5	17.30	0.009
Hydrocarbons	1	3.46	0.002
Nitrogen oxides	22	76.14	0.038

2A. Diesel powered generators

Source: 1) For 2,000 kw and 750 kw, manufacturer's typical expected emission rate is used

2) For 440 kw geneator, AP-42, compilation of Air Pollution Emission Factors

Emission factor:

1) For 2,000 KW or 2,682 HP
   NO_X = 9 gm/hp-hr
   CO = 0.5 gm/hp-hr
   HC = 1.25 gm/hp-hr

2) For 750 kw or 1,005 hp
   NO_X = 12 gm/hp-hr
   CO = 0.5 gm/hp-hr
   HC = 1.5 gm/hp-hr

3) For 440 kw

	#/hr
CO	0.434
Exhaust HC	0.160
NO_X	2.010
Aldehydes	0.030
SO_X	0.133
Particulates	0.143

Assumptions:

1) three diesel powered generators and one @ 2,000 kw, one @ 750 kw and one @ 440 kw

Calculations:

1) For 2,000 kw

NO_X

(9 gm/hp-hr) (2,682 hp) (4,320 hrs)

$= 104.27 \times 10^6$ gm

$= (104.27 \times 10^6 \text{ gm}) (0.002205 \frac{\#}{\text{gm}}) (\frac{1 \text{ T}}{2000\#})$

= 114.95 Tons

Following the same procedure, the CO emissions = 6.4 tons and the HC emissions = 16.0 tons

2) For 750 KW

NO_X

(12 gm/hp-hr) (1005 hp) (4,320 hrs)

= 52,099,200 gms

$= (52,099,200) (0.002205 \frac{\#}{\text{gm}}) (\frac{1 \text{ T}}{2000 \#})$

= 57.44 tons

Following the same procedures the CO emissions = 2.39 tons and HC emissions 7.17 tons.

3) For 440 KW

CO

(0.434 #/hr) (4,320 hrs)

= 1,874 #

= 0.94 tons

Following the same procedure

	Tons
Exhaust HC	0.346
NO_X	4.35
Aldehydes	0.06
SO_X	0.29
Particulates	0.31

Therefore, total emission from generators

NO_x	114.95 + 57.44 + 4.35 = 176.74 tons
CO	6.40 + 2.39 + 0.94 = 9.73 tons
HC	16.00 + 7.17 + 0.346 = 23.52 tons
Aldehydes	0.06 tons
SO_x	0.29 tons
Particulates	0.31 tons

2B. Diesel powered air compressors

Source: AP-42, Compilation of Air Pollutant Emission Factors

Emission factor:

	lb/hr/compressor*
Carbon Monoxide	0.434
Exhaust HC	0.160
Nitrogen Oxides	2.010
Aldehydes	0.030
Sulfur Oxides	0.133
Particulates	0.143

Assumptions:

(a) three diesel-powered air compressors, one @ 150 HP and one @ 100 HP and one 1,000 SCFM compressor

(b) six months of continuous operation

Calculations:

carbon monoxide = (00.434) (3)

= 1.30 #/hr

for 4,320 hrs = (1.30) (4,320)/2,000 #/T

= 2.81 T/yr

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* The emission factors for engines having a rated power range from 34 KW to 447 KW. The lower rated values are used since there are currently no emission factors for higher rated engines.

following the same method, the emission rate for other pollutants are as follows:

	lb/hr/compressor	For 3 compressors lbs/hr	Total emissions for 6 months (4,320 hrs) tons
Carbon Monoxide	0.434	1.30	2.81
Exhaust HC	0.160	0.50	1.04
Nitrogen Oxides	2.01	6.03	13.02
Aldehydes	0.03	0.09	0.19
Sulfur Oxides	0.133	0.34	0.86
Particulates	0.143	0.43	1.01

3. Pyrolysis

Source: AP-42, Compilation of Air Pollutant Emission Factors

Emission Factor: For combustion of propane

	$lb/10^3/gal$
Particulates	1.7
Sulfur Oxides	0.09s
Carbon Monoxide	1.5
Hydrocarbons	0.3
Nitrogen Oxides	11.2

Where: s equals sulfur content expressed in grains/100 ft^3 of vapor

Assumptions:

(a) sulfur content 15 grains/100 ft^3 of vapor

(b) 16,000 gallons of propane usage for two (2) days

Calculations:

Particulates: $(1.7\#/10^3 gal)$ (16,000 gal)

= 27.2 #

= 0.01 T

following the same method, the emission rates for the other pollutants are as follows:

	lb/10^3/gal	Lbs	Tons
Particulates	1.7	27.2	0.01
Sulfur Oxides	0.09s	21.6	0.01
Carbon Monoxide	1.5	24.0	0.01
Hydrocarbons	0.3	4.5	0.002
Nitrogen Oxides	11.2	179.2	0.09

4. Shaft ventilation

Source: Mine Safety and Administration

Emission Factor: 10 mg/m^3 nuisance standard for particulates

Assumptions:

1) Average cubic feet per minute of air through the shaft is 32,000 CFM

2) 6 months of continuous operations

Calculations:

(cu ft/min) (0.0283) = cu m/min

(32,000) (0.0283) = 905.6

$$(10\ mg/m3)\ \left(\frac{905.6 m^3}{min}\right)\ \left(\frac{60\ min}{hr}\right)\ \left(\frac{24\ hrs}{day}\right)\ \left(\frac{180\ days}{yr}\right)$$

$$\left(\frac{1g}{1{,}000\ mg}\right)\ \left(\frac{1\ kg}{1{,}000\ g}\right)\ \left(\frac{2.2\ \#}{1\ kg}\right)\ \left(\frac{1\ T}{2{,}000\ \#}\right)$$

= 2.58 Tons

Tons = 2.58

ASSUMPTIONS AND CALCULATIONS FOR AIR QUALITY IMPACT ANALYSIS

I. ASSUMPTIONS

(a) stability Class "F"

(b) wind speed, 3 meters/sec

(c) ground level point source

(d) source with no effective rise

(e) concentration is averaged over approximately 10 minutes

(f) receptor distance, 3 km downwind

(g) pyrolysis and boiler emissions and emissions from diesel generators and air compressors occur concurrently

II. ESTIMATED EMISSION STRENGTHS

1. Boiler Emissions - Duration of operation 20 days

	Boiler #/20 days	#/hr
Particulates	6.92	0.014
SO_2	149.50	0.31
CO	17.30	0.036
HC	3.46	0.007
NO_x	76.14	0.16

2. Diesel-Powered Generator and Air Compressors - Duration of operation 180 days

	#/hr
Particulates	0.14
SO_2	0.13
CO	4.50
HC	0.89
NO_x	81.80

3. Pyrolysis - Duration of operation 2 days

	#/2 days	#/hr
Particulates	27.2	0.57
SO_2	21.6	0.45
CO	24.0	0.50
HC	4.5	0.09
NO_x	179.2	3.73

4. Shaft Ventilation - Duration of operation 180 days

	T/180 days	#/hr
Particulates	2.58	1.19

5. Total Emissions, #/hr

Pollutant	Boiler	Generators/ Compressors	Pyrolysis	Shaft Ventilation	Total #/hr	Total g/sec
Particulates	0.014	0.61	0.57	1.19	2.38	0.3
SO_2	0.31	0.53	0.45	N/A	1.29	0.16
CO	0.036	5.80	0.50	N/A	6.33	0.80
HC	0.007	11.37	0.09	N/A	11.46	1.44
NO_x	0.16	87.85	3.73	N/A	91.74	11.56

III. AIR QUALITY IMPACT CALCULATIONS

For estimation of concentration of the source directly downwind (Y=o) from a ground level source, the following equation is used (Turner, 1969):

$$X\,(x,o,o,o) = \frac{Q}{y\ z\ u}$$

where

x = ground level concentrations (g/m^3)
Q = emission rate (g/sec)
y & z = horizontal and vertical plume standard deviations (m)
u = wind speed (m/sec)

y and z were calculated using figures A-1 and A-2.

Therefore, ground level concentration for particulates is

$$= \frac{(0.3 \text{ g/sec})}{TC(72.5)\ (30)\ (3)}$$

$$= 0.00001 \text{ g/m}^3$$

$$= 14.63 \text{ ug/m}^3$$

Following the same calculations, the ground level concentrations for SO_2, CO, HC and NO_x averaged over 10 minutes are:

	ug/m^3
SO_2	7.80
CO	39.01
HC	70.22
NO_x	563.74

To calculate ground level concentration averaged over 1-hour the following equation is used:

$$X_s = X_k \left(\frac{t_k}{t_s}\right)^P$$

where

X_s = desired concentration estimate

t_s = sampling time for desired estimate (1 hr)

X_k = concentration estimate for shorter sampling time

t_k = shorter sampling time (10 minutes)

P = a constant = 0.2

For particulates:

$$X1hr = (14.63 \text{ ug/m}^3) \left(\frac{10}{60}\right)^{0.2}$$

$$= (14.63) \left(\frac{1}{6}\right)^{0.2}$$

$$= (14.63)\ (0.698)$$

$$= 10.21 \text{ ug/m}^3$$

Following the same calculations, the ground level concentrations for SO_2, CO, HC and NO_x averaged over 1-hour are:

	ug/m^3
SO_2	5.44
CO	27.23
HC	49.01
NO_x	393.49

APPENDIX B

TABLE 1

MONTHLY AVERAGE AMBIENT AIR CONSTITUENT CONCENTRATIONS OF GASES AND PARTICULATES ($\mu g/m^3$) 1974-1975

Trailer	Item	Month												Annual
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
020	NO ($\mu g/m^3$)	1.9	0.7	3.4	*0.4	*0.3	9.6	17.8	*3.2	*0.4	9.1	*3.2	3.5	4.5
023		4.4	*12.8	14.7	0.4	*1.2	0.6	0.1	0.3	0.6	1.4	0.6	0.3	3.1
020	NO_2 ($\mu g/m^3$)	2.8	6.8	4.5	*2.5	*1.2	2.7	4.1	*0.3	*1.7	4.7	*3.0	7.9	3.5
023		2.4	*4.7	7.4	0.2	*0.4	0.9	0.5	0.0	1.5	1.0	0.1	0.7	1.7
020	O_3 ($\mu g/m^3$)	58.0	69.3	93.7	105.1	88.0	77.1	71.5	69.1	74.6	50.8	41.1	32.8	69.3
023		*31.4	28.0	42.4	85.8	85.6	90.5	87.3	84.4	86.1	61.0	53.4	43.3	64.9
020	Non-Methane H.C. ($\mu g/m^3$)	73.4	97.4	*75.7	23.4	38.6	327.6(2)	38.9	50.8	25.8	27.9	58.9	75.9	76.2
023		933.0(1)	20213.6(1)	*662.8(1)	22.1	*17.1	49.1	43.3	196.5	220.2	145.6	92.2	331.8	124.2
020	CH_4 ($\mu g/m^3$)	826.1	918.8	*908.1	879.4	829.8	590.6(2)	833.6	821.2	825.9	908.8	949.3	935.6	852.3
023		825.5	1053.8(1)	*943.6(1)	*833.7	*859.8	836.3	834.3	814.7	780.7	902.7	933.4	814.1	845.5
020	CO ($\mu g/m^3$)	553.8	676.9	908.2	1228.5(2)	1498.0(2)	*853.0(2)	1815.5(2)	1092.1(2)	206.5(2)	1117.2	1154.4	3742.8	1237.2
023		3703.6(1)	2439.3(1)	1786.2(1)	391.4	504.5	485.8	699.9	437.0	468.5	820.3	721.7	*3281.1	867.8
020	SO_2 ($\mu g/m^3$)	0	1.8	0	0.1	1.1	0.1	0	1.0	1.6	0.9	0.7	1.4	0.7
021		1.3	1.7	0.8	0.8	0.6	1.2	1.1	2.1	1.3	1.9	1.7	1.8	1.4
022		2.6	0.1	0	0.2	0	0	0.5	1.7	0.4	0.6	0	0.6	0.6
023		0	6.4	3.3	0.1	0.6	0.5	0	0.0	0.6	2.0	0.9	0.2	1.2
024		0.2	1.7	1.3	5.5	0.9	1.1	0.7	0.6	0.1	0.9	0.7	2.0	1.3
020	H_2S ($\mu g/m^3$)	0	0	0	0	0.4	0	0	0.2	0	0	0.1	0.1	0.1
021		1.6	0	0.2	0.8	0.4	0.2	0.4	0.7	0.2	0.4	0.7	0.8	0.5
022		0.2	1.2	0	0.2	0.3	0.7	0	0.4	0.2	0.3	0.4	0.2	0.3
023		0	5.2	2.5	0.7	2.7	0.5	0.3	0.3	4.8	2.4	2.1	0	1.8
024		0	0.1	0	0.2	0.4	1.0	0.3	1.1	0.1	0.1	0.6	1.0	0.4
020	Particulate ($\mu g/m^3$)	*48.7(3)	4.3	3.3	3.8	6.5	11.6	12.4	10.7	14.7	18.6	12.8	11.2	13.2
021		*20.4	5.4	4.0	4.5	6.9	13.7	13.2	12.3	15.6	14.3	12.4	12.4	11.3
022		*35.3	4.2	2.9	3.2	5.3	11.9	11.2	9.5	14.6	11.5	12.6	9.7	11.0
023		*18.0	*6.8	*2.5	4.2	11.5	15.4	19.3	18.3	14.4	11.7	11.1	13.7	12.2
024		*117.0	2.9	2.3	3.8	4.9	10.2	11.4	8.7	11.3	10.6	9.8	12.4	17.1

* 50% Or Less Data

(1) Reported data are incorrect because of contaminated manifold.

(2) Reported data may be incorrect because of possible malfunctioning instrument.

(3) Very few particulate data points available for November 1974. The values reported were unduly influenced by the occurrence of a few unusually high 24-hour concentrations.

SOURCE: C-b Oil Shale Plan, Detailed Development Plan, Volume 2, 1976

APPENDIX B

TABLE 2

TRACT MAXIMUM GAS CONCENTRATIONS ($\mu g/m^3$)
1974-1975

Trailer	Item	Averaging Time (Hr.)	Month											
			Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	NO	1	44.3	16.4	43.7	7.8	4.7	27.1	34.0	29.8	3.1	38.1	26.5	34.2
023	NO	1	38.5	93.9	114.2	52.6	16.7	10.1	4.2	28.7	15.3	17.0	16.5	9.0
020	NO_2	1	26.7	36.0	17.6	14.4	11.2	16.7	17.0	20.8	33.9	12.4	9.1	20.2
023	NO_2	1	21.2	47.0	68.2	9.2	4.8	10.1	8.0	3.7	13.2	59.9	9.3	7.6
020	O_3	1	108.1	117.9	130.9	146	146.2	115.3	124.5	160.4	130.9	114.0	80.8	56.2
023	O_3	1	64.6	68.5	97.7	136	145.9	116.1	139.5	152.2	129.9	127.0	135.3	58.0
020	Non-Methane H.C.	3 (6-9 A.M.)	197.6	179.7	223.8	51.4	288.6	707.7(2)	83.5	141.2	69.6	42.1	319.4	486.9
023	Non-Methane H.C.	3 (6-9 A.M.)	(1)	(1)	(1)	18.1	34.2	302.2	120.0	355.1(2)	895.6(2)	520.4	349.6	533.2
020	CH_4	3 (6-9 A.M.)	933.2	1219.5	999.2	1298.0	998.8	837.8	924.0	862.5	859.2	1009.0	1068.1	1342.9
023	CH_4	3 (6-9 A.M.)	(1)	(1)	(1)	900.1	910.2	902.4	903.9	879.1	879.4	979.5	1029.5	964.3
020	CO	1	1353.8	1853.7	1700.8	1716.6(2)	3680.4(2)	1811.5(2)	3296.9(2)	4650.9(2)	2065.3(2)	2147.1	2049.7	4227.9
023	CO	1	(1)	(1)	(1)	769.7	2421.1	740.9	1155.9	790.8	1635.9	1444.3	1763.3	4452.1
020			4.6	17.4	2.6	7.6	32.8	7.2	7.6	20.8	33.9	12.4	9.1	20.2
021			32.8	25.8	53.4	23.2	21.3	21.7	34.3	67.9	18.2	16.9	11.3	20.8
022	SO_2	1	13.0	20.8	5.9	11.7	14.1	2.6	18.2	27.4	14.5	16.3	2.4	13.0
023			0.2	97.9	50.6	5.0	12.2	8.2	7.2	3.7	13.2	59.9	9.3	7.6
024			5.2	128.5	54.3	34.3	50.8	49.1	56.4	33.0	10.6	26.5	20.6	41.7
020			10.1	2.2	6.2	13.7	12.5	2.2	1.2	21.7	2.9	5.9	1.7	2.1
021			58.9	4.6	4.7	9.5	7.3	4.3	9.0	13.8	3.5	8.3	6.9	13.8
022	H_2S	1	4.7	8.4	2.4	14.3	14.1	10.1	1.3	11.9	5.7	4.3	3.8	11.9
023			3.2	45.3	28.4	8.2	19.1	6.5	6.9	8.0	71.2	38.5	15.1	1.8
024			8.3	7.7	27.6	8.1	8.5	62.5	56.9	70.9	3.0	8.5	10.4	20.9

(1) Reported data incorrect due to manifold contamination

(2) Reported data may be incorrect because of possible malfunctioning instrument.

SOURCE: C-b Oil Shale Plan, Detailed Development Plan, Volume 2, 1976

APPENDIX B

TABLE 3

ANNUAL SUMMARY OF AIR QUALITY PARAMETERS
(FEBRUARY 1975 THROUGH JANUARY 1976), RBOSP

Parameter	Units	Minimum**	Maximum**	Arithmetic Mean
		Site 1		
O_3	ppm	0.000	0.068	0.033
CO	ppm	0.000	3.241	0.618
NO	ppm	0.000	0.047	0.003
NO_x	ppm	0.000	0.076	0.004
CH_4	ppm	0.095	1.526	1.059
THC	ppm	0.837	1.745	1.163
H_2S	ppm	0.000	0.027	0.001
SO_2	ppm	0.000	0.057	0.003
Particulates	$\mu g/m^3$	< 0.06† ††	211.47†	9.07*
		Site 2		
CH_4	ppm	0.045	1.567	1.075
THC	ppm	0.188	1.821	1.198
H_2S	ppm	0.000	0.034	0.002
SO_2	ppm	0.000	0.041	0.002
Particulates	$\mu g/m^3$	0.06†	101.66†	9.20*
		Site 3		
O_3	ppm	0.000	0.089	0.030
CO	ppm	0.000	4.584	0.645
NO	ppm	0.000	0.159	0.004
NO_x	ppm	0.000	0.154	0.005
CH_4	ppm	0.781	1.860	1.147
THC	ppm	0.895	2.768	1.233
H_2S	ppm	0.000	0.012	0.002
SO_2	ppm	0.000	0.023	0.001
Particulates	$\mu g/m^3$	0.74†	247.03†	18.00*
		Site 4		
CH_4	ppm	0.356	1.545	1.087
THC	ppm	0.523	1.802	1.165
H_2S	ppm	0.001	0.065	0.005
SO_2	ppm	0.000	0.060	0.007
Particulates	$\mu g/m^3$	0.25†	469.28†	12.61*

* Geometric Mean
** Hourly Average
† Calculated from 24-hr batch sample
†† LDL of particulate measurement technique

SOURCE: Rio Blanco Oil Shale Project, Detailed Development Plan Tract C-a, Volume 2, 1976

APPENDIX

TABLE 4

HIGH VOLUME FILTER ANALYTICAL TRACE ELEMENT RESULTS, RBOSP

PARAMETER	CONCENTRATION (ng/cm^2)			
	SPRING	SUMMER	FALL	WINTER**
Uranium	<0.01	Internal Standard	<0.18	0.11
Thorium	<0.01	<0.01	0.56	0.25
Bismuth	<0.01	<0.01	0.49	0.12
Lead	45	19	12	9.5
Thallium	<0.01	<0.01	<0.47	<0.01
Mercury	NR*	0.1	0.2	0.3
Gold	<0.01	<0.01	<0.10	<0.01
Platinum	<0.01	<0.01	<0.10	<0.01
Iridium	<0.01	<0.01	<0.10	<0.01
Osmium	<0.01	<0.01	<0.10	<0.01
Rhenium	Internal Standard	Internal Standard	Internal Standard	Internal Standard
Tungsten	<0.01	<0.01	<0.36	<0.01
Tantalum	<0.01	<0.01	2.3	<0.01
Hafnium	<0.01	<0.01	<0.10	<0.01
Lutecium	<0.01	<0.01	<0.10	<0.01
Ytterbium	<0.01	<0.01	<0.10	<0.01
Thullium	<0.01	<0.01	<0.10	<0.01
Erbium	<0.01	<0.01	<0.10	<0.01
Holmium	<0.01	<0.01	<0.10	<0.01
Dysprosium	<0.01	NR*	<0.10	<0.01
Terbium	<0.01	<0.01	<0.10	<0.01
Gadolinium	<0.01	<0.01	<0.10	<0.01
Europium	<0.01	<0.01	<0.10	<0.01
Samarium	<0.01	<0.01	<0.10	<0.01
Neodymium	<0.01	<0.01	0.28	<0.01
Praseodymium	<0.01	0.23	0.73	<0.01
Cerium	3.5	11	3.1	0.39
Lanthanum	1.6	2.8	0.78	0.54
Barium	21	56	34	6.4
Cesium	<0.01	0.16	<0.10	<0.01
Iodine	<0.01	<0.01	0.26	<0.01
Tellurium	<0.01	<0.01	<0.10	<0.01
Antimony	<0.01	0.25	0.14	0.27
Tin	0.96	5.1	0.66	0.86
Indium	Internal Standard	Internal Standard	Internal Standard	Internal Standard
Cadmium	<0.01	<0.01	<0.10	<0.01
Silver	<0.01	<0.01	0.47	<0.01
Palladium	<0.01	<0.01	<0.10	<0.01
Rhodium	<0.01	<0.01	<0.10	<0.01
Ruthenium	<0.01	<0.01	<0.10	NR*
Molybdenum	19	13	2.0	0.73
Niobium	0.50	1.4	1.1	0.45
Zirconium	2.2	5.6	5.8	0.96
Yttrium	0.91	2.1	0.63	0.18
Strontium	12	12	38	3.5
Rubidium	4.2	9.5	5.6	0.57
Bromine	1.8	1.6	0.30	0.79
Selenium	<0.01	0.37	1.5	0.21
Arsenic	1	<0.62	4.0	2.4
Germanium	<0.01	<0.01	<0.10	<0.01
Gallium	<0.01	1.7	1.8	<0.01
Zinc	<0.01	36	11	58
Copper	76	470	170	170
Nickel	<0.01	<75	7.7	5.8
Cobalt	NR*	<7	0.84	0.22
Iron	NR*	~1400	3400	NR*
Manganese	NR*	<38	91	6.7
Chromium	NR*	<28	21	6.7
Vanadium	5.3	6.4	11	5.8
Titanium	380	510	650	42
Scandium	<0.01	0.42	0.42	<0.01
Calcium	~1700	~3500	10000	770
Potassium	≈2200	~1240	6000	450
Chlorine	43	67	4.8	31
Sulphur	530	<520	660	160
Phosphorus	82	170	800	130
Silicon	≈4800	~75000	82000	NR*
Aluminum	670	~2100	14000	NR*
Magnesium	960	~1500	4200	230
Sodium	High Blank	<740	2000	290
Fluorine	420	62	340	71
Oxygen	NR*	NR*	NR*	NR*
Nitrogen	NR*	NR*	NR*	NR*
Carbon	NR*	NR*	NR*	NR*
Boron	0.01	NR*	NR*	NR*
Beryllium	0.01	<0.01	0.19	<0.01
Lithium	5.0	37	2.7	1.0

NR* = Not Reported

**December, 1975 - January, 1976

SOURCE: Rio Blanco Oil Shale Project, Detailed Development Plan Tract C-a, Volume 2, 1976

APPENDIX B

TABLE 5

Ambient Concentrations of Trace Elements on
Composite Samples
Concentrations in $\mu g/m^3$

	Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples		Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples		Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples		Composite of Winter, 1974 Samples	Composite of Spring, 1975 Samples	Composite of Summer, 1975 Samples	Composite of Fall, 1975 Samples
Uranium	7×10^{-5}	2×10^{-3}			Terbium					Ruthenium					Vanadium	4×10^{-4}	2×10^{-4}		
Thorium	6×10^{-5}				Gadolinium					Mclybdenum	2×10^{-4}				Titanium	4×10^{-3}	6×10^{-3}		
Bismuth	2×10^{-5}	1×10^{-4}			Europium					Niobium	6×10^{-5}				Scandium				
Lead	3×10^{-3}	2×10^{-3}			Samarium					Zirconium	3×10^{-4}				Calcium	.3	.44		
Thallium					Neodymium	4×10^{-4}	1×10^{-4}			Yttrium	1×10^{-4}	1×10^{-4}			Potassium	.1	.26		
Mercury	2×10^{-5}	2.05×10^{-8}			Praseodymium	3×10^{-5}	2×10^{-5}			Strontium	3×10^{-3}	2×10^{-4}			Chlorine	1×10^{-3}			
Gold					Cerium	1×10^{-4}	1×10^{-4}			Rubidium	2×10^{-3}	9×10^{-4}			Sulphur	7×10^{-3}	6×10^{-2}		
Platinum					Lanthanum	9×10^{-5}	5×10^{-5}			Bromine		1×10^{-4}			Phosphorus	3×10^{-3}	4.2×10^{-2}		
Iridium					Barium	1×10^{-3}	1×10^{-3}			Selenium	8×10^{-7}	6×10^{-5}			Silicon		.42		
Osmium					Cesium	7×10^{-5}				Arsenic	1×10^{-4}	1×10^{-3}			Aluminum	.1	2×10^{-2}		
Rhenium		Internal Standard			Iodine					Germanium	3×10^{-5}				Magnesium	.2	3.6		
Tungsten	4×10^{-5}				Tellurium					Gallium	1×10^{-4}	1×10^{-5}			Sodium	5×10^{-2}	4.2		
Tantalum					Antimony	5×10^{-5}	8×10^{-5}			Zinc	1×10^{-2}	9×10^{-3}			Fluorine	1×10^{-2}			
Hafnium					Tin	6×10^{-4}	2×10^{-4}			Copper	9×10^{-3}	6×10^{-2}			Oxygen		NR		
Lutecium					Indium		Internal Standard			Nickel	4×10^{-4}	3×10^{-4}			Nitrogen		NR		
Ytterbium					Cadmium					Cobalt	3×10^{-4}				Carbon		NR		
Thullium					Silver	6×10^{-5}	2×10^{-5}			Iron	3×10^{-2}	2.6			Boron	2×10^{-2}			
Erbium					Palladium					Manganese	3×10^{-3}	7×10^{-2}			Beryllium	2×10^{-7}			
Holmium					Rhodium					Chromium	7×10^{-4}				Lithium	1×10^{-4}			
Dysprosium					Radium	2.7×10^{-15}	2.7×10^{-15}								Radium				

Notes: NR – Not reported
When no number appears, concentration is less than 1×10^{-5} $\mu g/m^3$

APPENDIX B

Air Standards and Control Plans

a. Ambient Standards

The Clean Air Act of 1970 required EPA to promulgate primary air quality standards to protect human health with a margin of safety and secondary standards to protect public welfare. The standards apply to sulfur dioxide, suspended particulates, carbon monoxide, photochemical oxidants, non-methane hydrocarbons, and nitrogen dioxide. Short and long term values were specified for both classifications. Compliance with these standards will be obtained by proper consideration of meteorological (dispersion) parameters in the detailed engineering design of all stacks or other potential emission sources and by fuel management policies. The National Ambient Air Quality Standards (NAAQS) are shown in Table 6.

b. Prevention of Significant Deterioration (PSD)

The U.S. Congress recently promulgated and made law plans intended to prevent significant air quality deterioration. These plans provide for three classes of areas, each with a maximum allowable increment of air quality degradation. As of the effective date of the law all international parks, national wilderness areas greater than 5000 acres, national memorial parks greater than 5000 acres, and national parks greater than 6000 acres are designated as class I areas. All other areas are designated as class II. The law provides a scheme for reclassifying class II and III areas. Table 7 gives the PSD standards.

At present, the law applies only to sulfur dioxide and suspended particulates, but it also provides that the EPA promulgate similar standards for NO_X, O_X, CO, and HC's.

For areas that have air quality poorer than that allowed by the ambient standards (NAAQS), a new source of emissions must offset these emissions by eliminating an equal quantity in the local area.

Another provision of the non-deterioration regulations calls for a review by the EPA of selected types of new sources, including petroleum refineries and fuel conversion plants. As part of this review, the EPA must evaluate air pollution control technology to be utilized by the proposed new source, and must prescribe emission limitations or equipment standards which will correspond to the use of "best available technology" for control of particulates and sulfur dioxide.

c. New Stationary Source Performance Standards

The EPA has promulgated New Stationary Source Performance Standards which prescribe design and operating requirements for certain categories of new sources. The State of Colorado has incorporated the

APPENDIX B

TABLE 6

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Pollutant	Averaging[a] Time	Primary[b] Standards	Secondary[c] Standards
Sulfur Dioxide	Annual arithmetic mean	80 μgm/m^3 (0.03 ppm)	---
	24 hr.	365 μgm/m^3 (0.14 ppm)	---
	3 hr.	---	1300 μgm/m^3 (0.5 ppm)
Suspended particulate matter	Annual geometric mean	75 μgm/m^3	60 μgm/m^3
	24 hr.	260 μgm/m^3	150 μgm/m^3
Carbon monoxide	8 hr.	10 mg/m^3 (9 ppm)	Same as primary standard
	1 hr.	40 mg/m^3 (35 ppm)	
Photochemical oxidants (corrected for NO_2 and SO_2)	1 hr.	160 μgm/m^3 (0.08 ppm)	Same as primary standard
Hydrocarbons (corrected for methane)	3 hr. (6 to 9 a.m.)	160 μgm/m^3 (0.24 ppm)	Same as primary standard
Nitrogen dioxide	Annual arithmetic mean	100 μgm/m^3 (0.05 ppm)	Same as primary standard

a. The 1-, 3-, 8-. and 24-hour standards are maximum concentrations not be exceeded more than once per year.

b. Primary standards are intended to protect public health.

c. Secondary standards are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

APPENDIX B

TABLE 7

FEDERAL PSD STANDARDS
Allowable Increments, $\mu g/m^3$

Particulate Matter	Class I	Class II	Class III
Ann. Geom. Mean	5	19	37
24-Hour Maximum	10	37	75
Sulfur Dioxide			
Ann. Arith. Mean	2	20	40
24-Hour Maximum	5	91	182
3-Hour Maximum	25	512	700

Total concentrations limited to those prescribed by National Ambient Air Quality Standards

APPENDIX B

TABLE 8

AMBIENT AIR STANDARDS FOR
METROPOLITAN DENVER AIR QUALITY CONTROL REGION,
AIR QUALITY CONTROL AREAS,
AND THE STATE OF COLORADO

Suspended Particulate Matter

	Suspended Particulate Matter: (a) (Micrograms Per Cubic Meter - $\mu g/m^3$)			
		Metro-Denver Air Quality Control Region, and Designated State Areas		
	Non-Designated Areas	1973	1976	1980
Short Term(b)	150	200	180	150
Long Term(c)	45	70	55	45

(a) Measured at ambient conditions.

(b) Short term level - A 24-hour maximum of any 24-hour period and must not be exceeded more than once in a 12-month period.

(c) Long term level - An annual arithmetic mean of all 24-hour concentrations.

APPENDIX B

TABLE B

AMBIENT AIR STANDARDS FOR
METROPOLITAN DENVER AIR QUALITY CONTROL REGION,
AIR QUALITY CONTROL AREAS,
AND THE STATE OF COLORADO

Suspended Particulate Matter

	Suspended Particulate Matter (a) (Micrograms Per Cubic Meter - $\mu g/m^3$)			
	Non Designated Areas	Metro-Denver Air Quality Control Region and Designated State Areas		
		1973	1974	1980
Short Term(b)	150	200	190	150
Long Term(c)	75	70	55	45

(a) Measured at ambient conditions

(b) Short term level - A 24-hour maximum of any 24-hour period and must not be exceeded more than once in a 12-month period.

(c) Long term level - An annual arithmetic mean of all 24-hour concentrations

standards for all but one of these categories into its regulations. These New Stationary Source Performance Standards will be discussed below under Colorado Regulation No. 6. In addition, EPA has also promulgated performance specifications for continuous monitors. These have been incorporated into Colorado Regulation No. 6.

d. National Emission Standards for Hazardous Pollutants

Emission standards for hazardous pollutants such as asbestos, beryllium and mercury have been established. Approximately 500 materials are regulated by this standard.

Various standards and regulations have been adopted by the Colorado Air Pollution Control Commission (APCC) and are administered by the Air Pollution Control Division (APCD) of the Colorado Department of Health. Those regulations which would apply to shale oil operations are discussed below.

(1) Ambient Standards

The State of Colorado has adopted ambient air quality standards for particulates and sulfur dioxide, described as follows:

Particulates

Standards for suspended particulate matter as absolute values are defined for "designated" and "non-designated" areas as shown in Table 8. The Piceance Creek basin is currently a non-designated area (Figure 1).

Sulfur Dioxide

Under revised standards recently passed by the Colorado APCC, allowable increments of SO_2 concentration are defined for three different categories as indicated in Table 9.

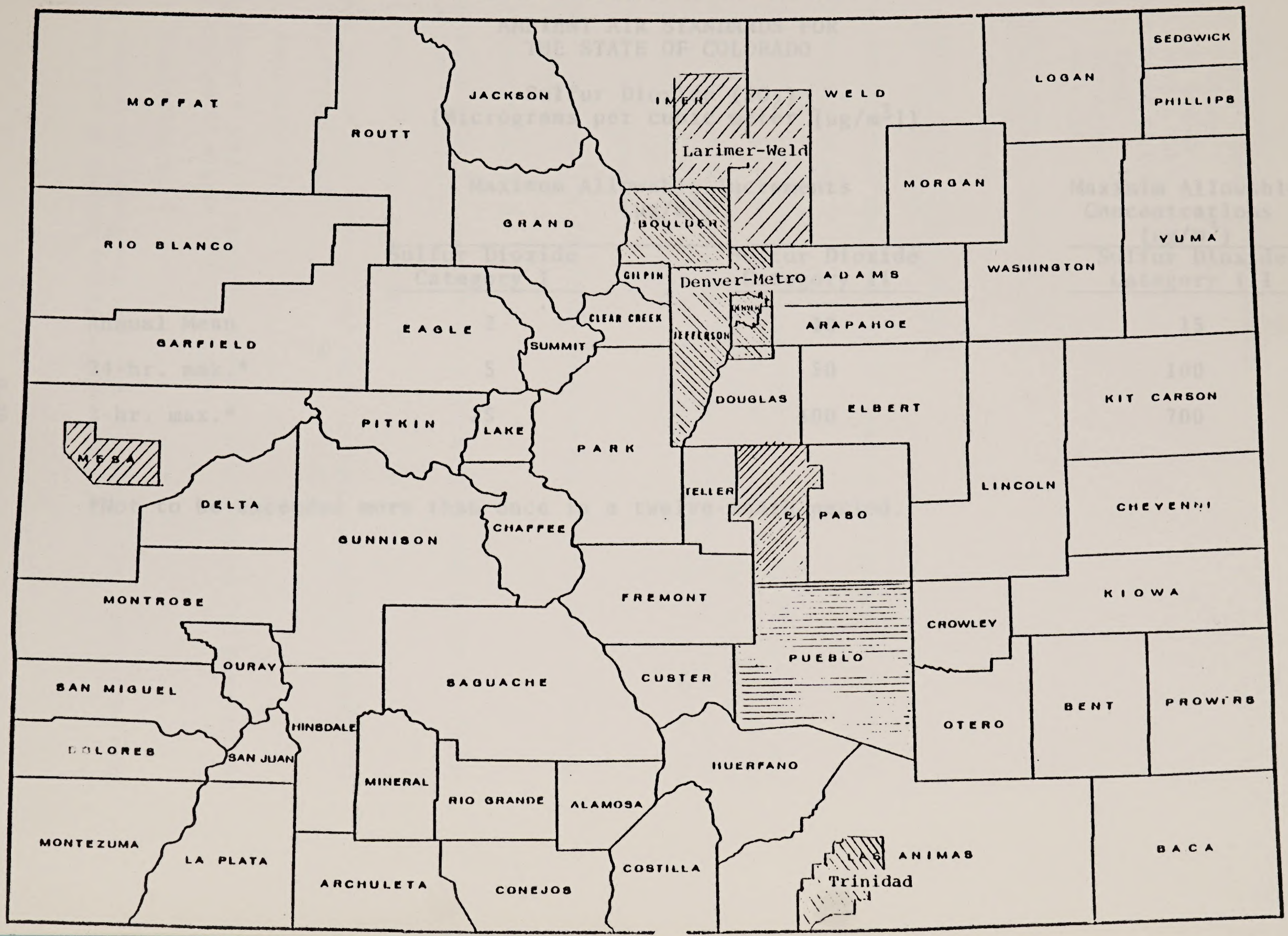
The following areas of the state have been designated as Colorado Category I.

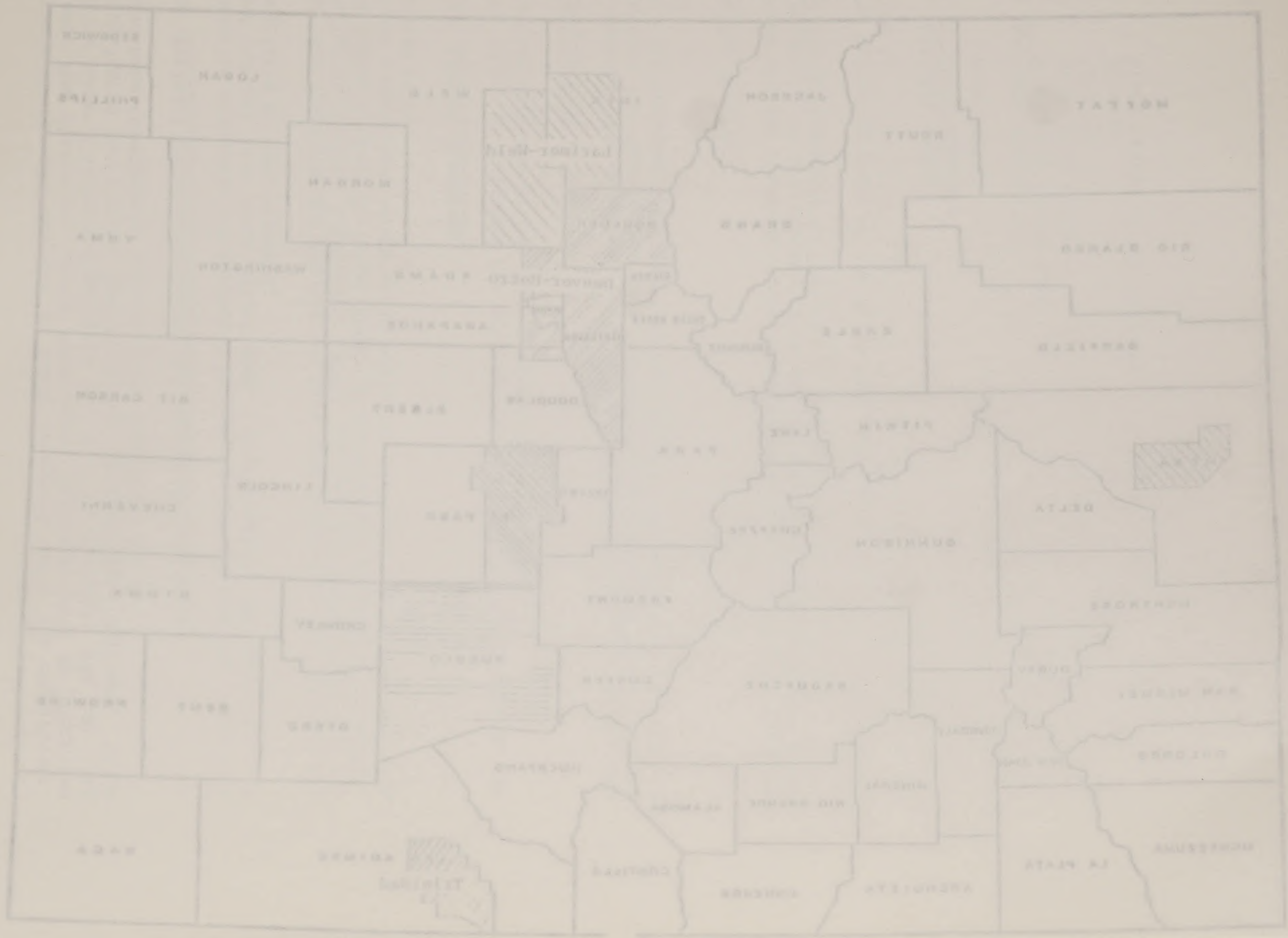
- NATIONAL PARKS
  - Rocky Mountain
  - Mesa Verde
- NATIONAL MONUMENTS
  - Florissant Fossil Beds
  - Great Sand Dunes
  - Colorado
  - Dinosaur
  - Black Canyon of the Gunnison

APPENDIX B

FIGURE 1

STATE AIR POLLUTION CONTROL AREAS





APPENDIX B

TABLE 9

AMBIENT AIR STANDARDS FOR
THE STATE OF COLORADO

Sulfur Dioxide (SO_2)
(Micrograms per cubic meter [$\mu g/m^3$])

	Maximum Allowable Increments ($\mu g/m^3$)		Maximim Allowable Concentrations ($\mu g/m^3$)
	Sulfur Dioxide Category I	Sulfur Dioxide Category II	Sulfur Dioxide Category III
Annual Mean	2	10	15
24-hr. max.*	5	50	100
2-hr. max.*	25	300	700

*Not to be exceeded more than once in a twelve-month period.

APPENDIX B

TABLE 9

AMBIENT AIR STANDARDS FOR
THE STATE OF COLORADO

Maximum Allowably Increments ($\mu g/m^3$)		Maximum Allowable Concentrations ($\mu g/m^3$)
Sulfur Dioxide	Sulfur Dioxide	Sulfur Dioxide
Category I	Category II	Category III
Annual Mean	2	10	15
24-hr. max.*	5	50	100
3-hr. max.*	25	100	700

*Not to be exceeded more than once in a twelve-month period.

- FOREST SERVICE WILDERNESS AREAS
  - Eagle's Nest
  - Flattops
  - La Garita
  - Maroon Bells - Snowmass
  - Mount Zirkel
  - Rawah
  - Weminuche
  - West Elk
- FOREST SERVICE PRIMITIVE AREAS
  - Uncompahgre
  - Wilson Mountain
- GUNNISON GORGE RECREATION AREA
  - BLM - administered land

The remainder of the state is at present designated as class II.

(2) Regulation No. 1

Regulation 1 limits the emission from any source to 20 per cent opacity. The regulation also limits the amount of allowed particulate emissions and is dependent upon the process. The regulation also limits fugitive dust emission to 20 per cent opacity and lists control measures for numerous activities. SO_2 emissions are also limited and is a function of the process.

(3) Regulation No. 2

Regulation 2 applies to odorous emission and is a function of location of the odor.

(4) Regulation No. 3

Regulation 3 details the permitting system to be used by the Air Pollution Control Division.

(5) Regulations No. 4 and No. 5

These regulations address wood waste burners and alfalfa dehydration units, respectively.

(6) Regulation No. 6

Regulation 6 details specific standards of performance for new stationary sources of eleven different types.

(7) Regulation No. 7

This regulation limits the emission of hydrocarbon vapors from many sources such as storage tanks, solvent useage, etc.

BLM - Administered land

- GUNNISON COUNCE RECREATION AREA

Wilson Mountain
Duncombe Gulch

- FOREST SERVICE PRIMITIVE AREAS

  - West Elk
  - Mcmurdo
  - Ramsey
  - Mount Zirkel
  - Marvine Peak - Zimmerman
  - La Garita
  - Piedras
  - Eagle's Nest

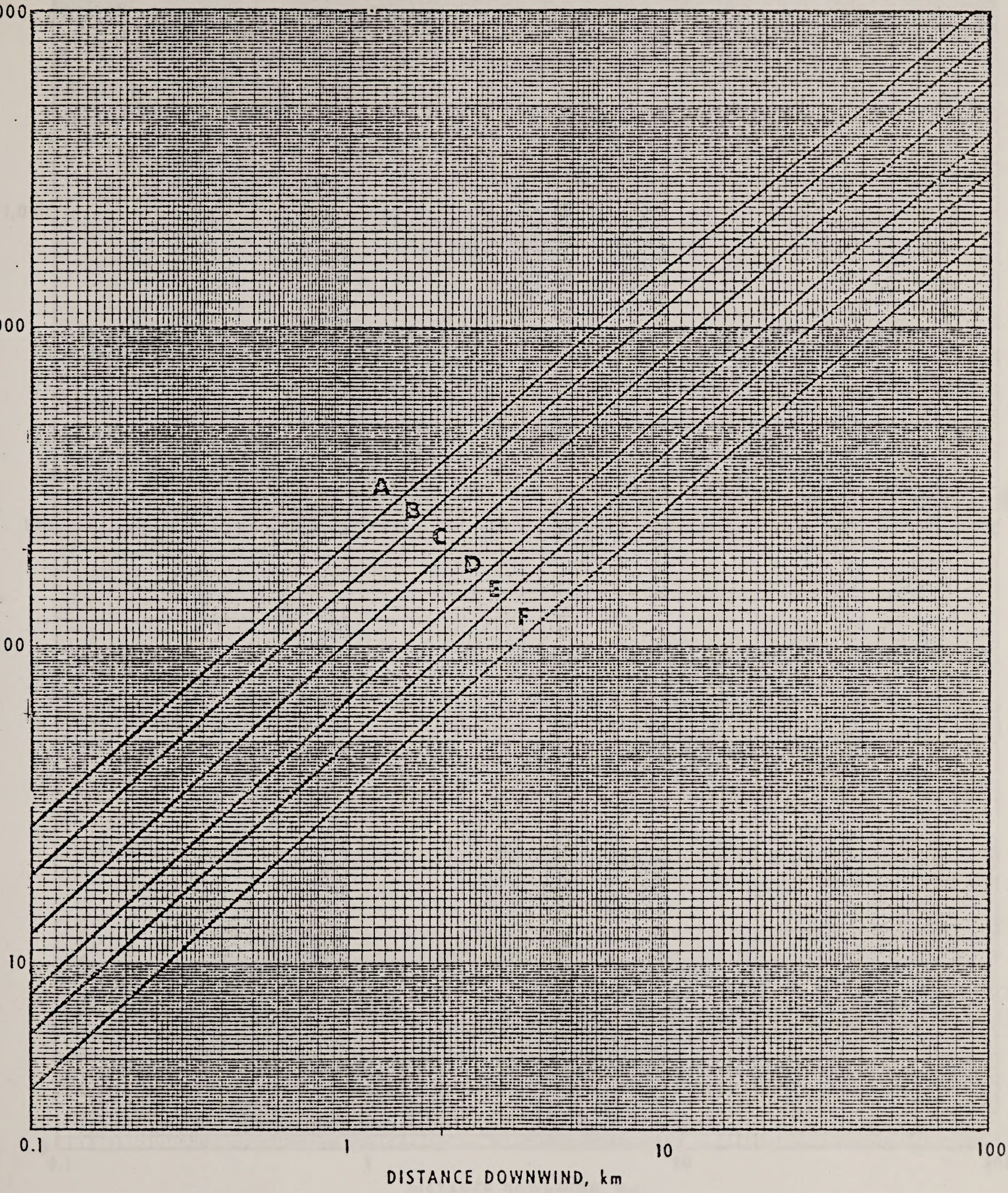
- FOREST SERVICE WILDERNESS AREAS

(8) Regulation No. 8

Regulation 8 was designed to limit the emission of some 500 hazardous materials. However, due to a flaw in wording the regulation is presently unenforcable. Substances, however, are controlled at this time.

(9) Regulation No. 9

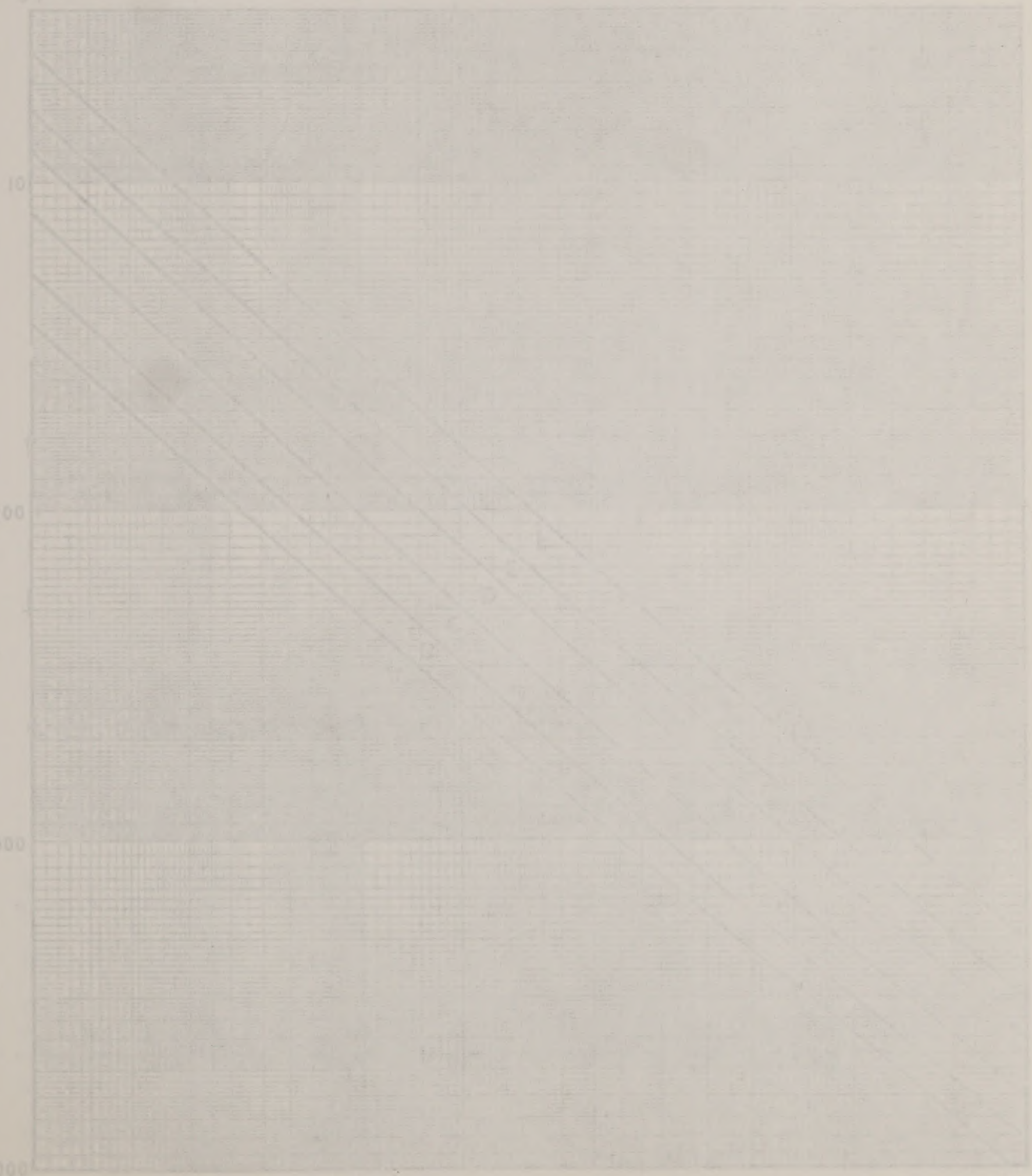
Regulation 9 addresses the emissions from automotive sources and details plans of control.

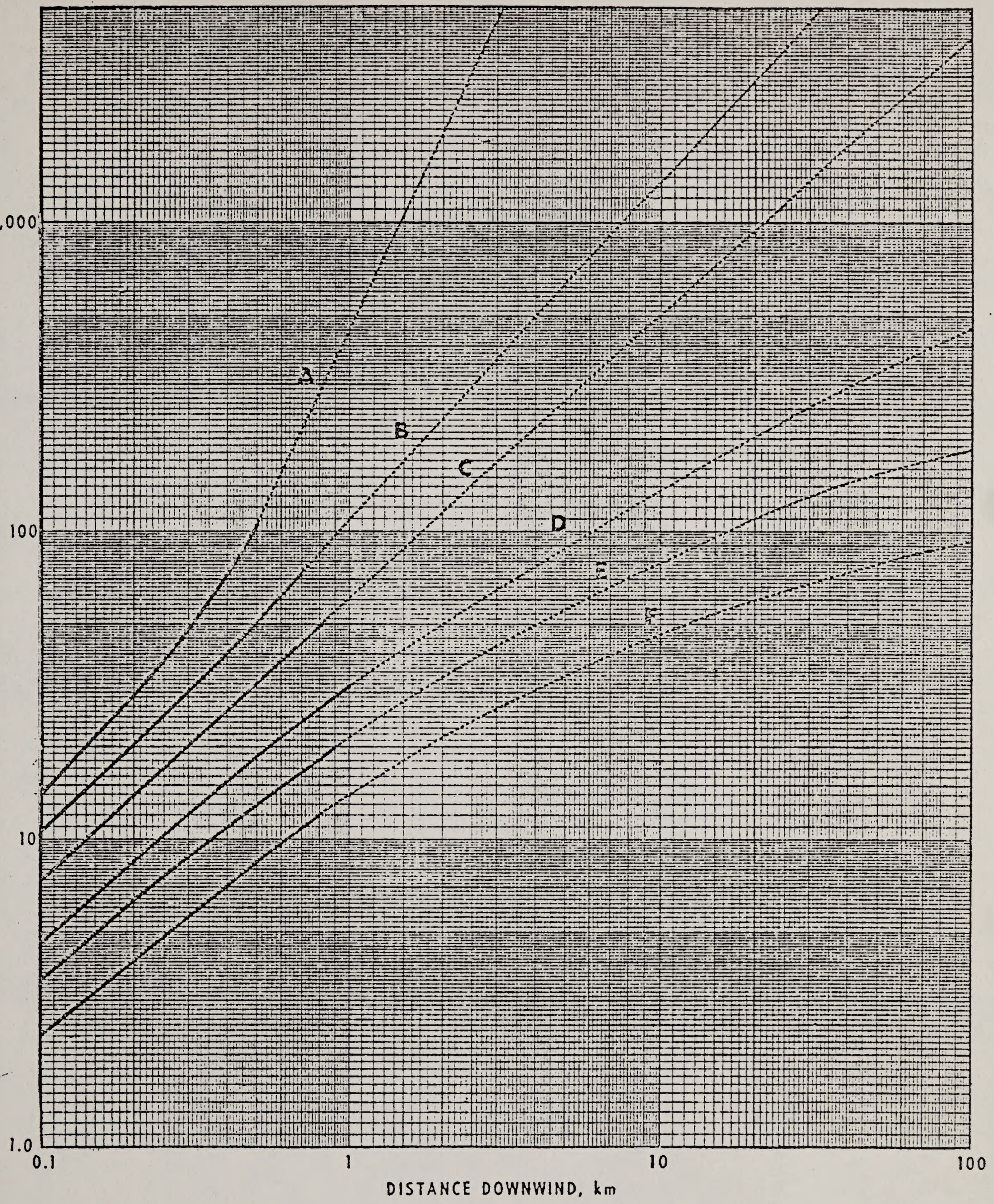


HORIZONTAL DISPERSION COEFFICIENT AS A FUNCTION OF DOWNWIND DISTANCE FROM THE SOURCE

Source: Turner, D. Bruce, 1969. Workbook of Atmospheric Dispersion Estimates, U.S. Department of Health, Education and Welfare.

APPENDIX B
FIGURE 2

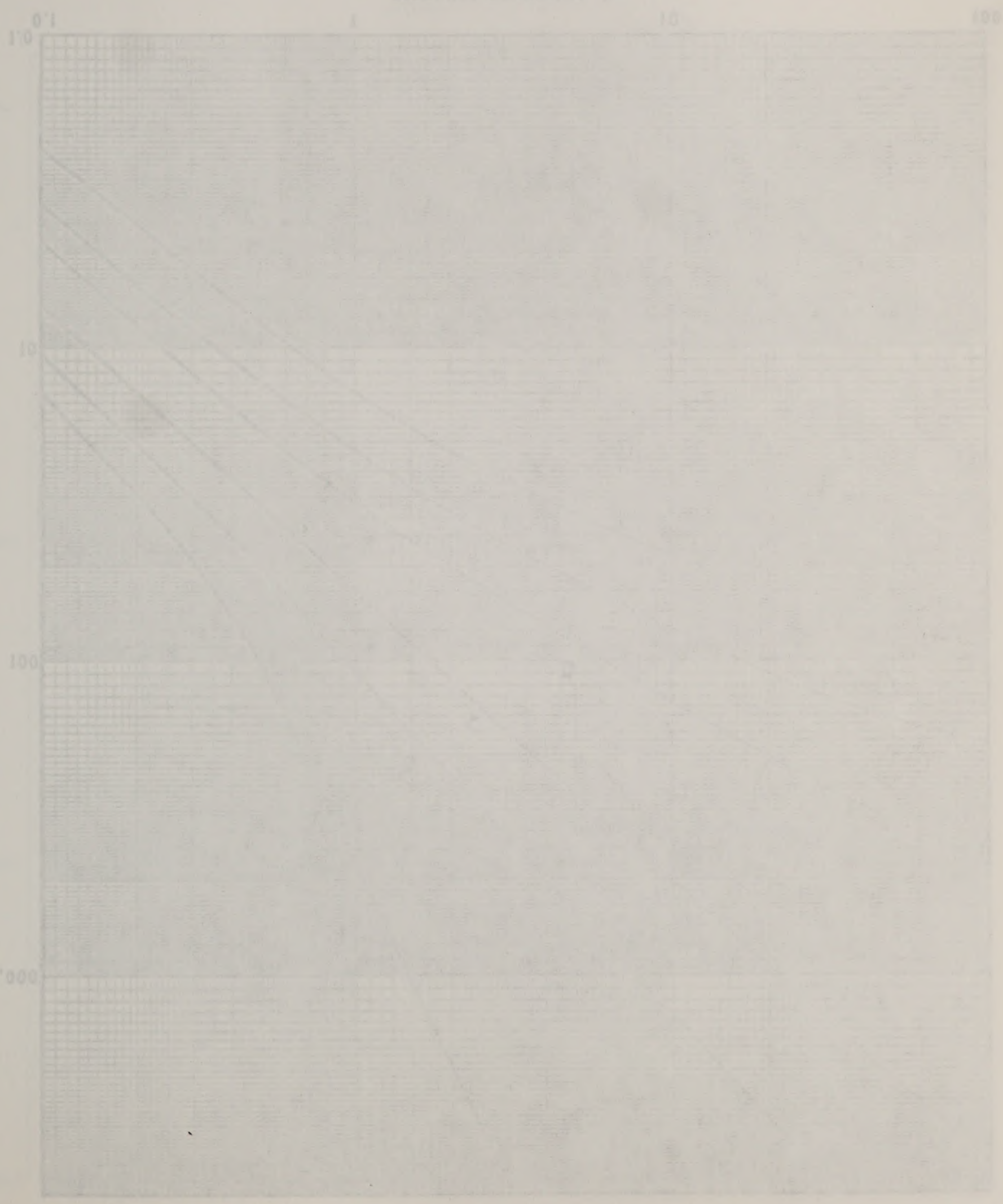




VERTICAL DISPERSION COEFFICIENT AS A FUNCTION OF DOWNWIND DISTANCE FROM THE SOURCE

Source: Turner, D. Bruce, 1969. Workbook of Atmospheric Dispersion Estimates, U.S. Department of Health, Education and Welfare.

APPENDIX B
FIGURE 3



APPENDIX C

GEOLOGY AND SOILS

APPENDIX C

SOIL CHEMISTRY

	SOIL TYPE		
MAP UNIT	Rentsac Channery 63	Piceance Loam 41	Hagga Loam 9
Texture	SN CL LO (Medium)	CL LO (Medium)	SI CL LO (Medium)
% ORGANIC	2.7	1.4	1.2
% LIME	2.4	3.4	1.8
PH-H2O	7.9	8.3	8.0
NITRATE-NITROGEN ppm	50.3	18.6	35.1
AMMONIA-NITROGEN ppm	6.8	1.3	2.1
PHOSPHORUS ppm	14.0	6.0	1.0
POTASSIUM ppm	230.0	50.0	55.0
CALCIUM ppm	3600.0	3800.0	3300.0
MAGNESIUM ppm	420.0	540.0	610.0
SULFATE-SULFUR ppm	2.0	10.0	19.0
IRON ppm	3.9	1.7	3.0
MANGANESE ppm	2.6	6.5	6.8
BORON ppm	1.0	0.4	0.2
SODIUM ppm	94.3	105.8	105.8
ESP	0.5	0.2	0.2
OMN	108.0	56.0	48.0
S.A.R.	2.0	4.5	2.4
% GYPSUM	-0.1	-0.1	-0.1
BULK DENSITY	1.60	1.54	1.45
PERMEABILITY IN.	0.49	0.36	0.30
% FLD CAP 1/3 BAR.	27.5	34.8	35.4
% FLD CAP 15 BAR.	18.8	20.6	21.0
MOLYBDENUM ppm	0.4	0.3	0.4
COBALT ppm	-0.1	0.1	-0.1
SELENIUM ppm	-0.01	-0.01	-0.01
ARSENIC ppm	0.03	0.03	0.06
FLUORIDE ppm	0.21	0.30	0.31
NICKEL ppm	0.8	1.2	1.5
LEAD ppm	-1.0	-1.0	-1.0
MERCURY ppm	0.002	0.003	0.005
CADMIUM ppm	-0.1	-0.1	-0.1
ANTIMONY ppm	-1.0	-1.0	-1.0

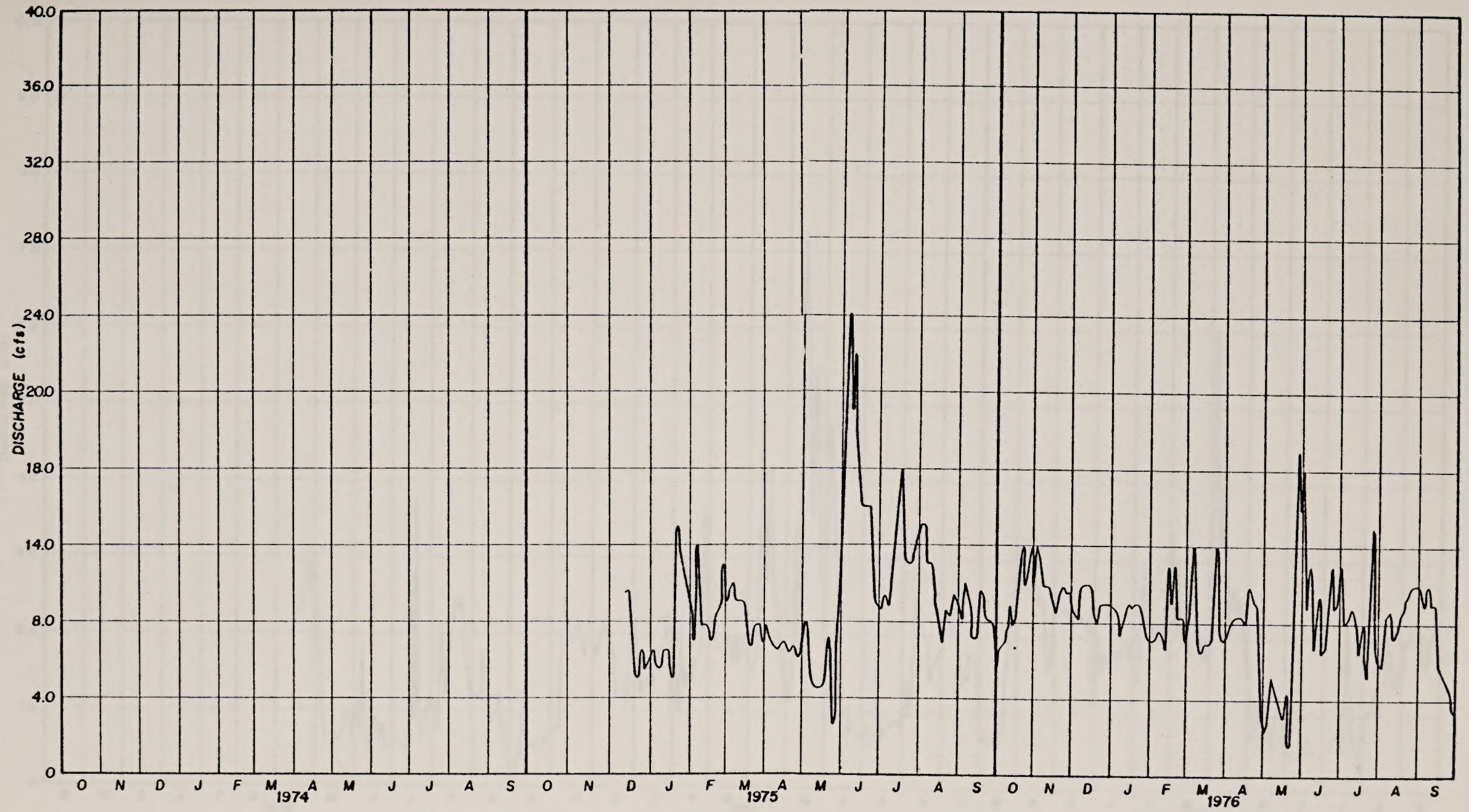
APPENDIX C
(Continued)

ABBREVIATIONS:

CEC:	Cation Exchange Capacity in MG Equiv/100gm.
ESP:	Exchangeable Sodium Percentage
SALE-EC:	Electrical Conductivity of Saturated Soil Past Extract in MCMHOS/CC
OMN:	Estimated Nitrogen Available to Plants in One
SN:	Sand or Sandy
SI:	Silt or Silty
CL:	Clay
LO:	Loam or Loamy
S A R:	Sodium Absorption Ratio
-:	Indicates Level is Below Reporting Minimum
*:	This Table Summarizes the Analyses from the Top Horizon of Each Soil Listed

APPENDIX D

SURFACE HYDROLOGY



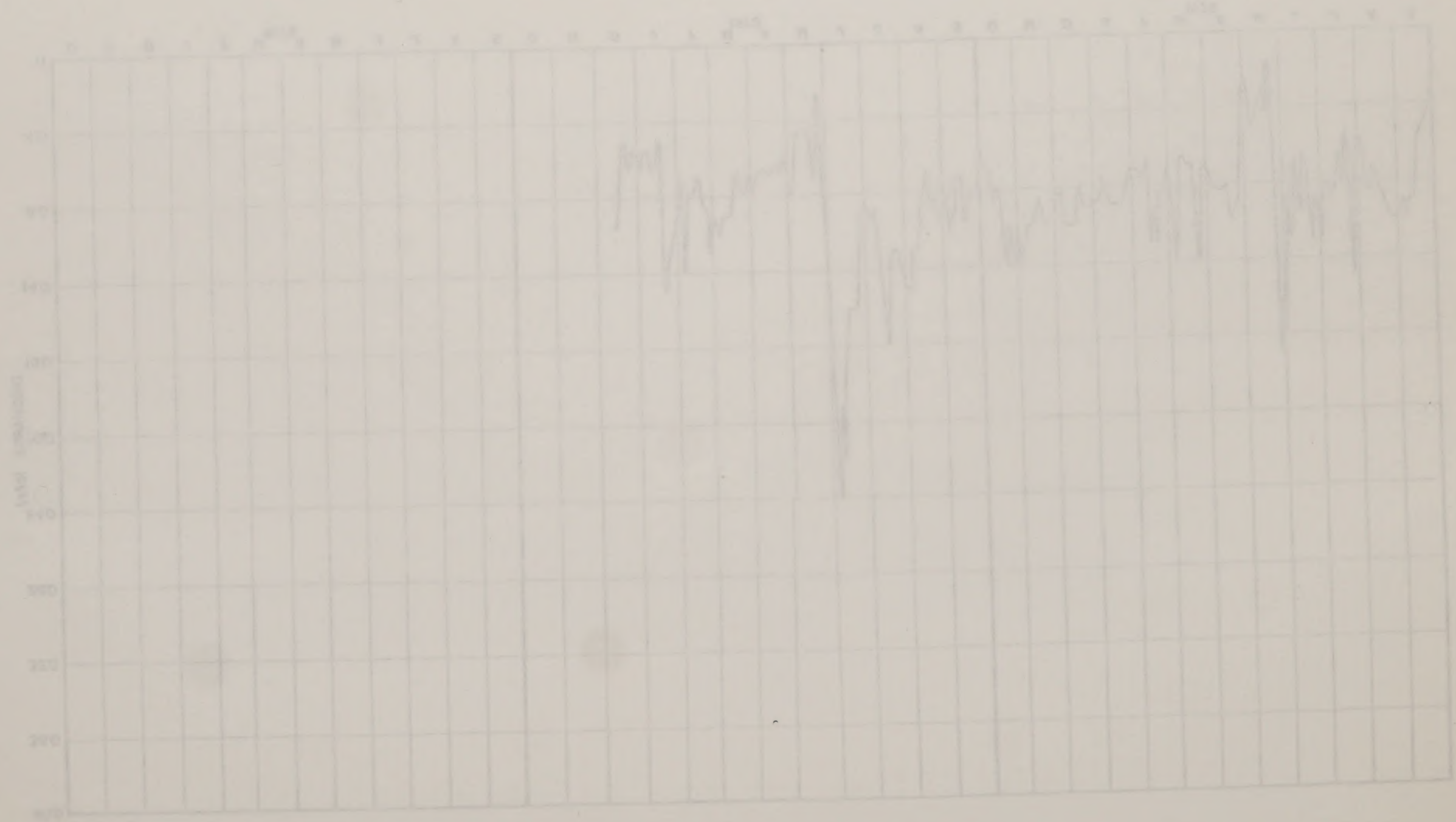
MEAN DAILY DISCHARGE AT STATION NO. 09306175

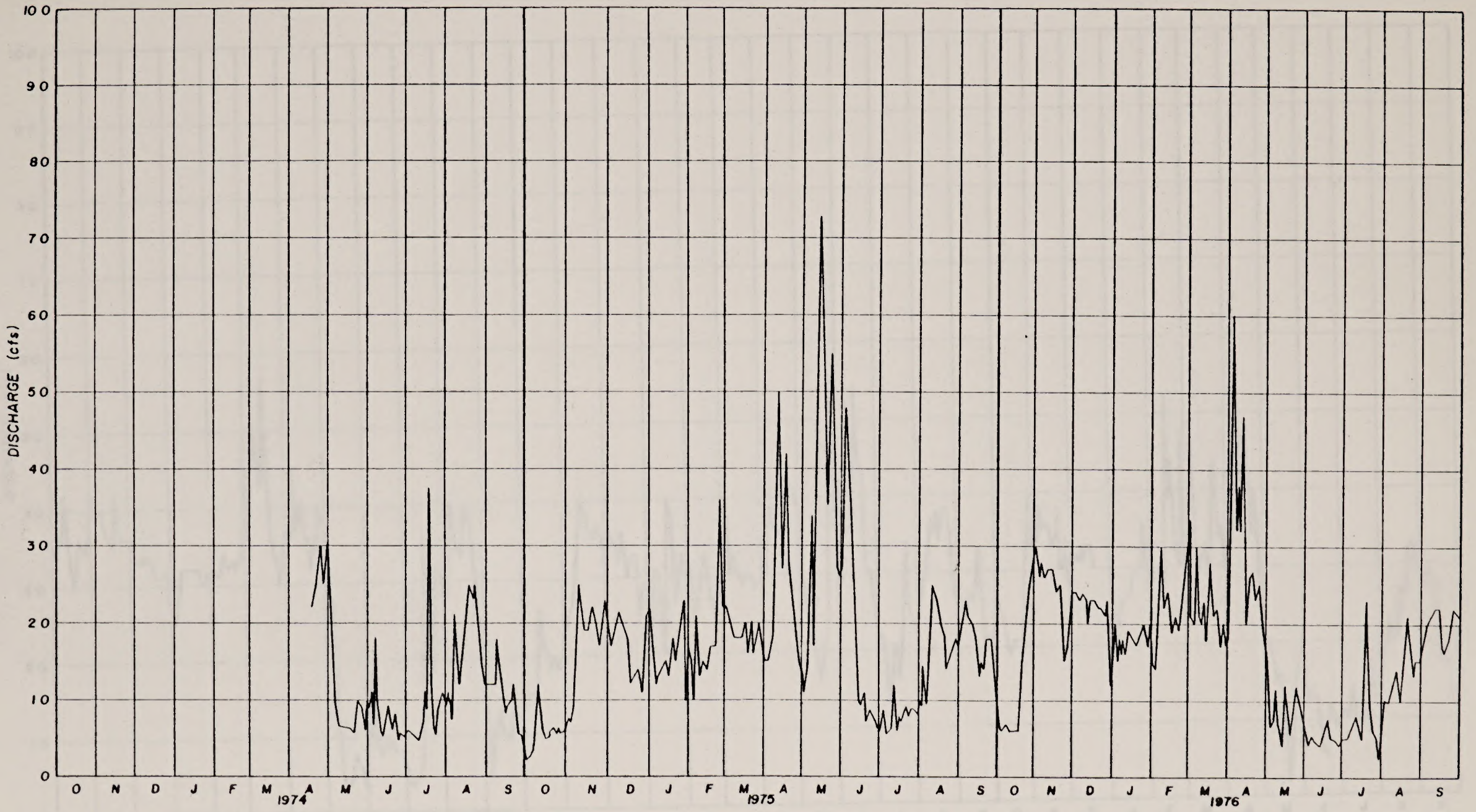
OCTOBER 1974 – SEPTEMBER 1976

SOURCE : USGS

APPENDIX D

FIGURE 1





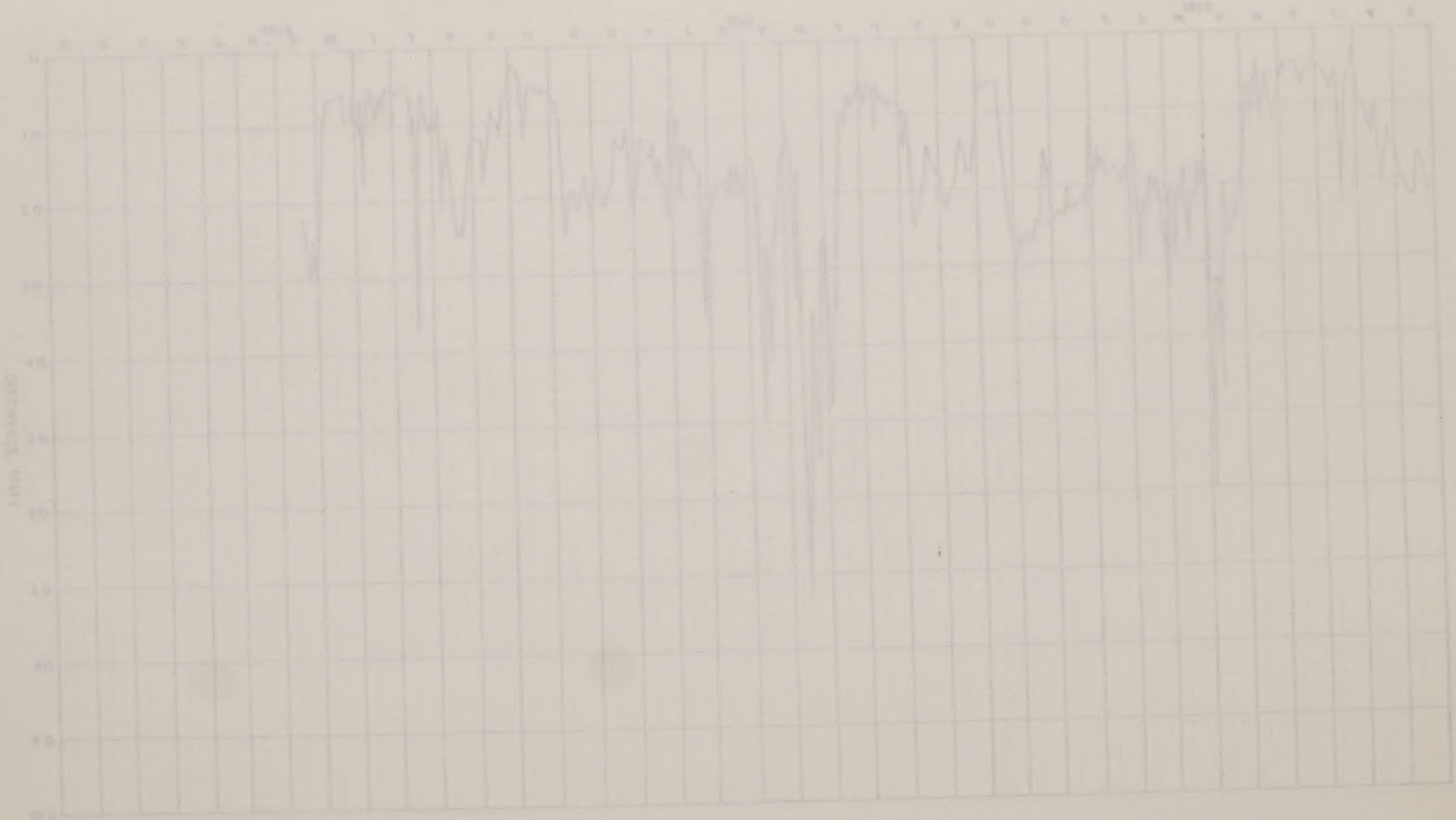
MEAN DAILY DISCHARGE AT STATION NO. 09306061

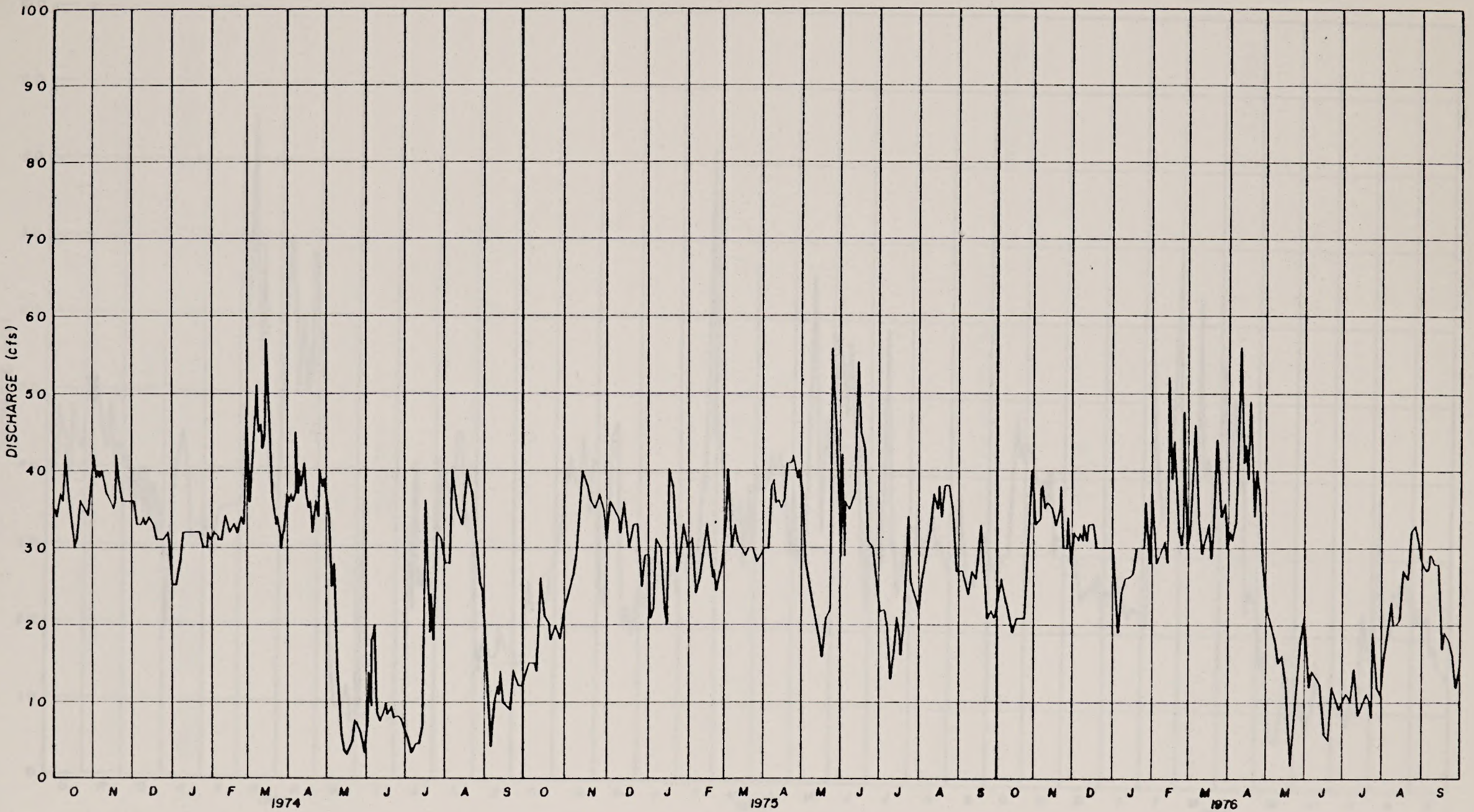
OCTOBER 1974 - SEPTEMBER 1976

SOURCE : USGS

APPENDIX D

FIGURE 2





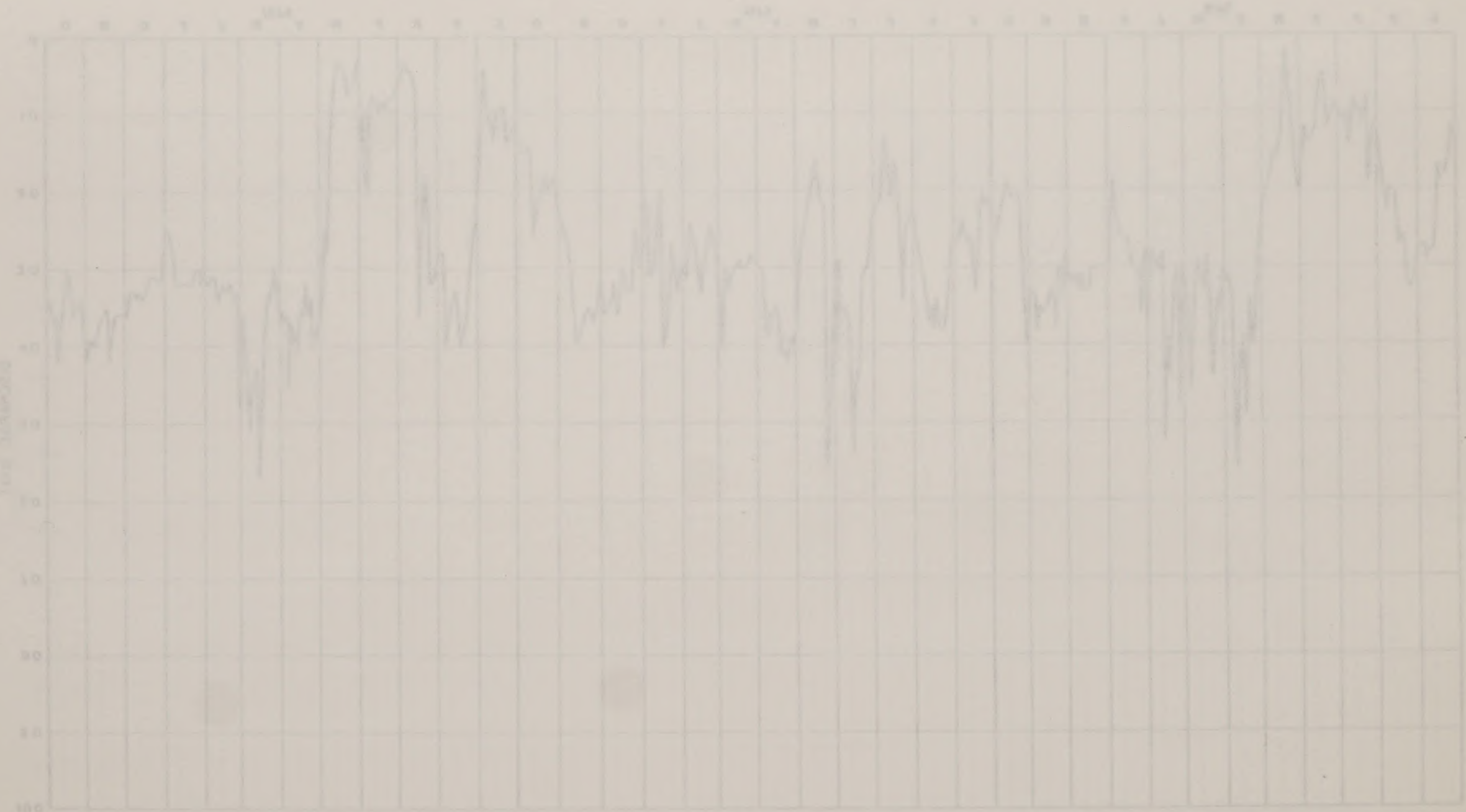
MEAN DAILY DISCHARGE AT STATION NO. 09306200

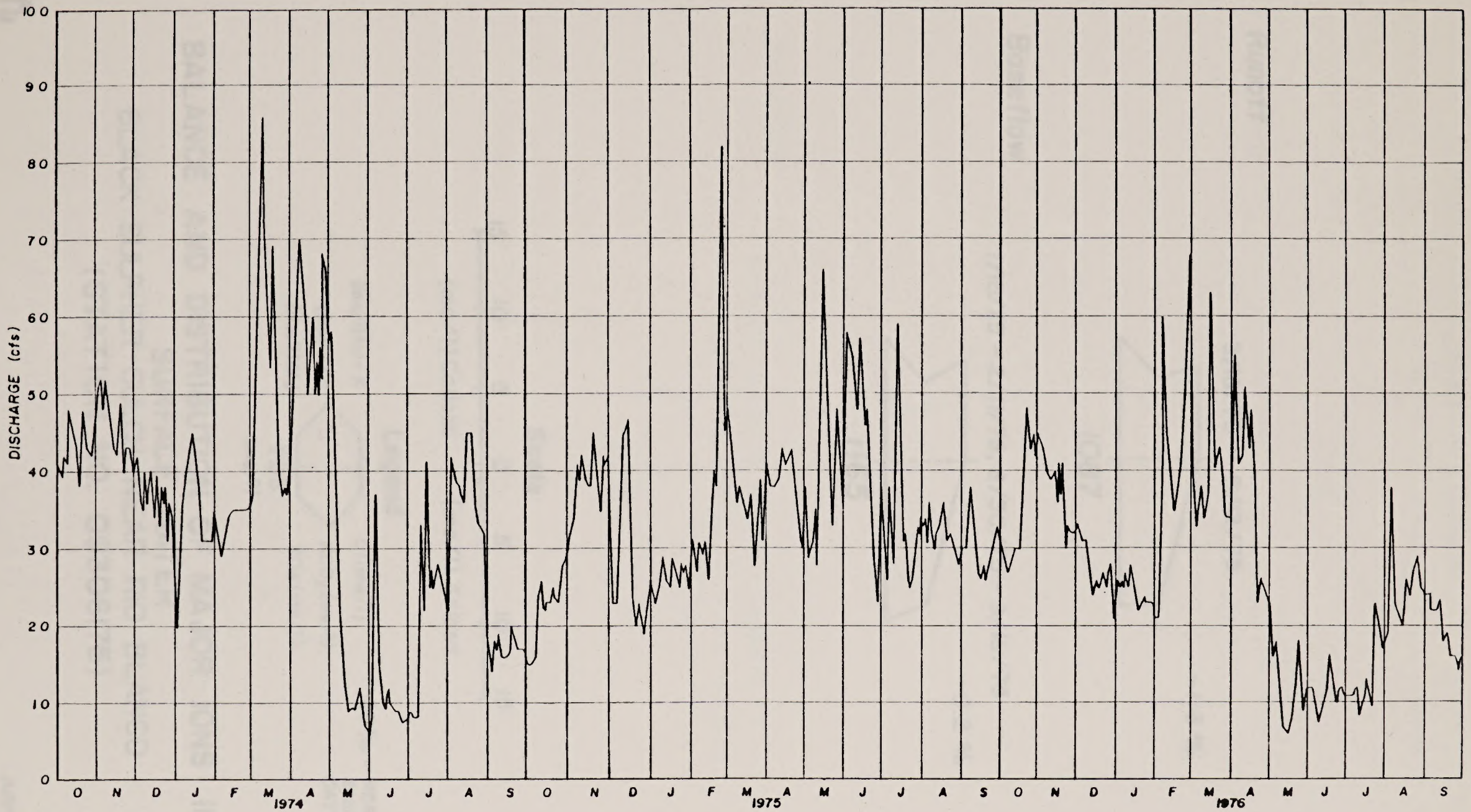
OCTOBER 1974 - SEPTEMBER 1976

SOURCE : USGS

APPENDIX D

FIGURE 3





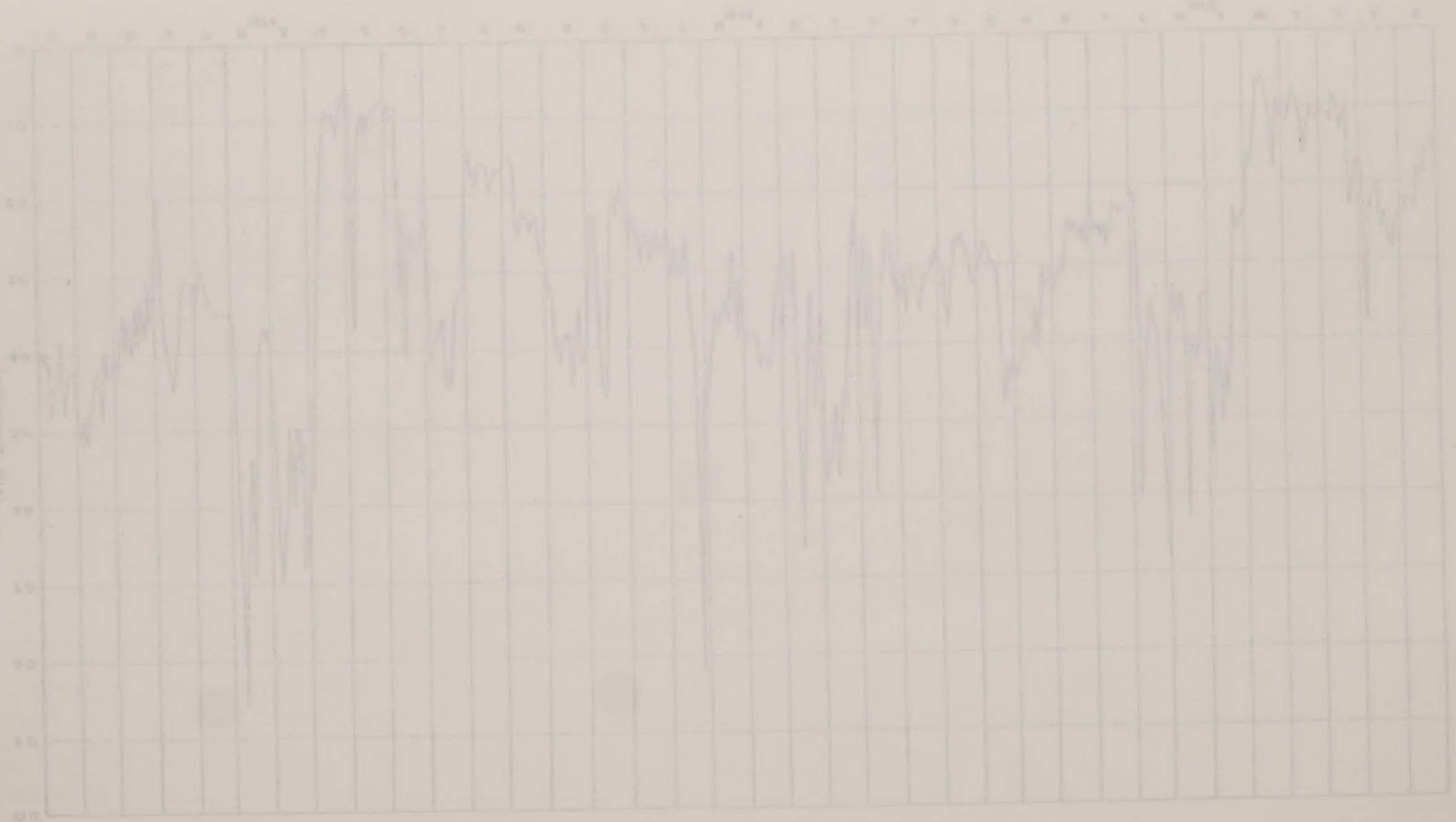
MEAN DAILY DISCHARGE AT STATION NO. 09306222

OCTOBER 1974 – SEPTEMBER 1976

SOURCE : USGS

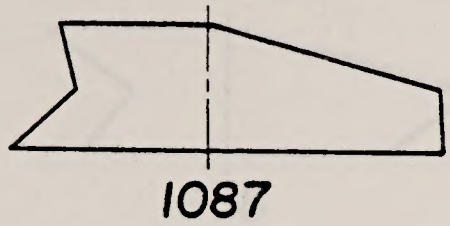
APPENDIX D

FIGURE 4



Runoff

3/18/75 - 6/12/75

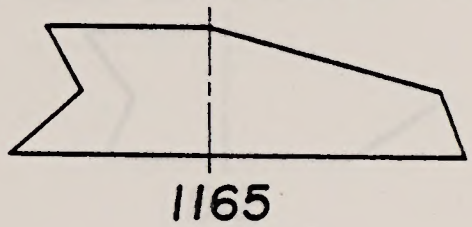


-1.3 %

1087

Baseflow

1/15/75 - 2/11/75, 6/30/75 - 9/18/75



-0.2 %

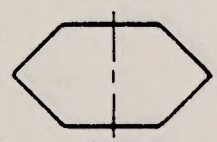
1165

Scale

15 10 5 0 5 10 15

(me/l) Cations (me/l) Anions

Legend



(me/l) Na + K
(me/l) Ca
(me/l) Mg
TDS (mg/l)
Cl (me/l)
HCO_3 (me/l)
SO_4 (me/l)

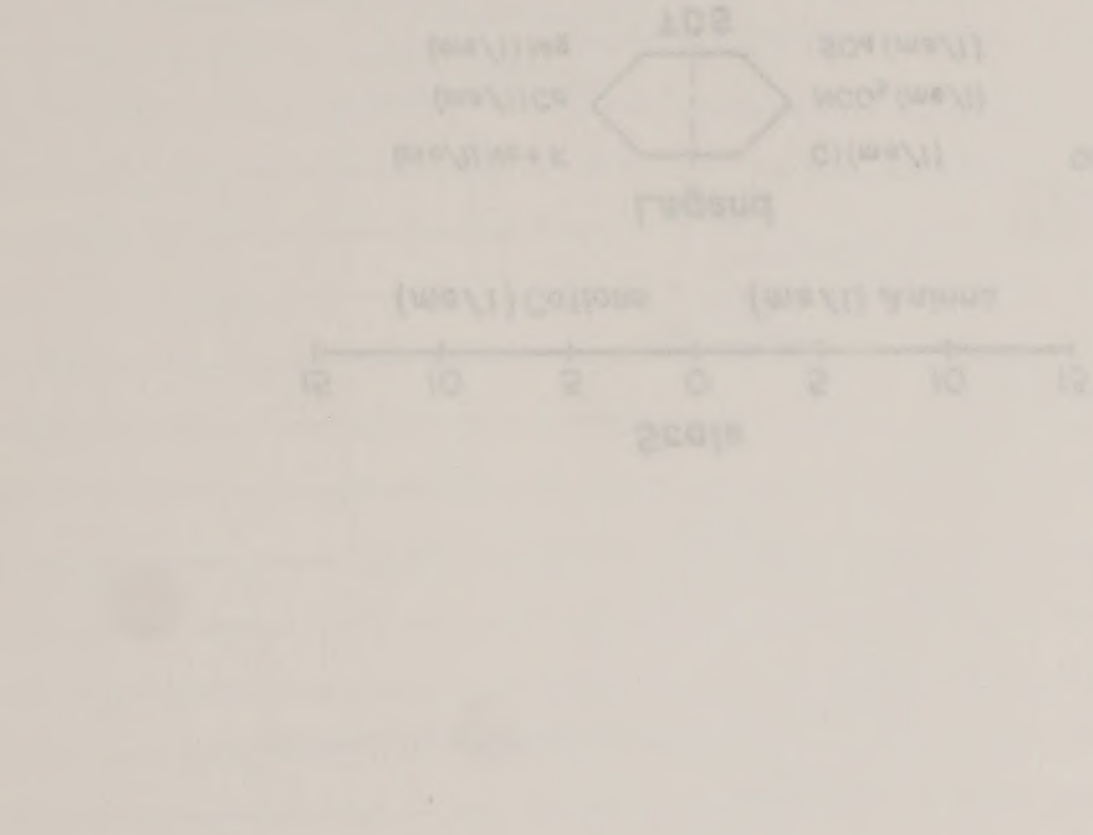
00% = PERCENT WHICH ANIONS EXCEED CATIONS

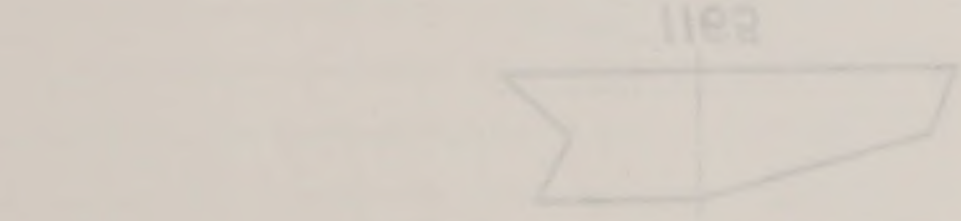
BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
BLACK SULPHER GULCH NEAR RIO BLANCO
(STATION NO. 09306175)

APPENDIX D
FIGURE 5

FIGURE 5

BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER BLACK SULPHER GULCH NEAR RIO BLANCO (STATION NO. 09380175)





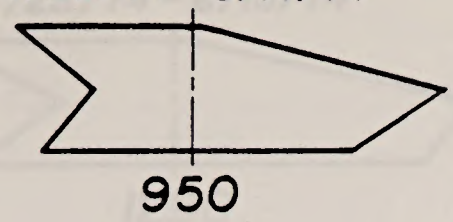
Boron



Bromine

Runoff

4/23/74 - 6/14/74

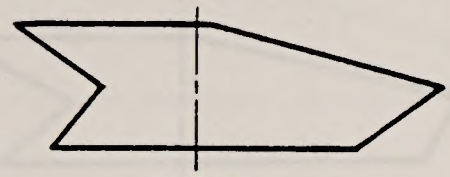


950

-1.3 %

Baseflow

6/21/74 - 9/26/74

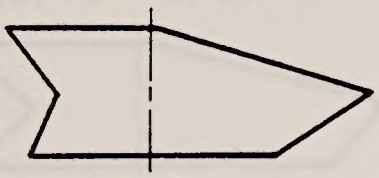


938

-2.8 %

Runoff

3/6/75 - 6/19/75

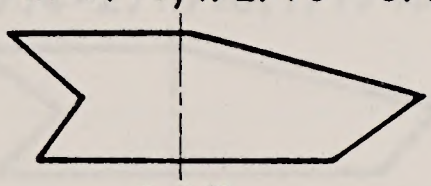


812

-2.5 %

Baseflow

10/4/74 - 2/19/75, 7/2/75 - 9/18/75



927

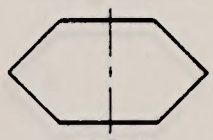
-1.6 %

Scale

15 10 5 0 5 10 15

(me/l) Cations (me/l) Anions

Legend



(me/l)Na+K
(me/l)Ca
(me/l)Mg

Cl(me/l)
HCO_3(me/l)
SO_4(me/l)

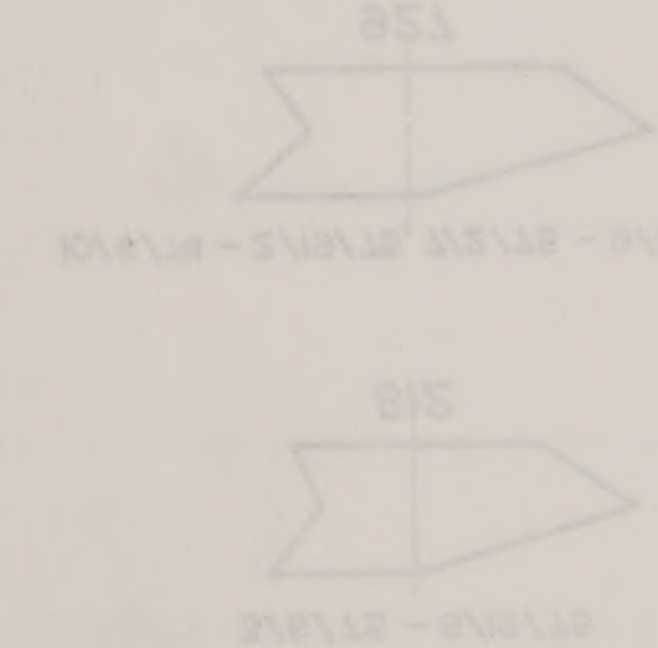
TDS (mg/l)

00% = PERCENT WHICH ANIONS EXCEED CATIONS

BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
PICEANCE CREEK ABOVE HUNTER CREEK
(STATION NO. 09306061)

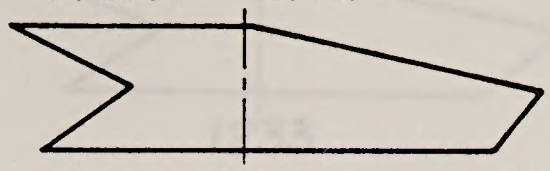
APPENDIX D

FIGURE 6



Runoff

3/28/74 - 6/10/74

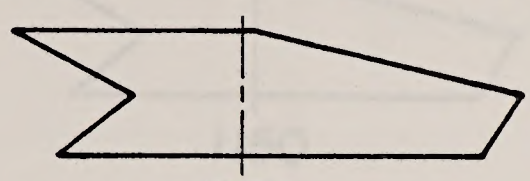


+1.2%

1290

Baseflow

10/4/73 - 2/14/74 , 7/3/74 - 9/25/74

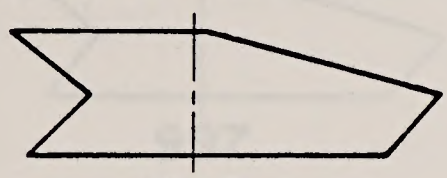


0.0%

1221

Runoff

3/18/75 - 6/9/75

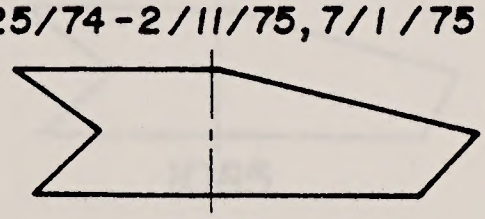


-1.7%

1042

Baseflow

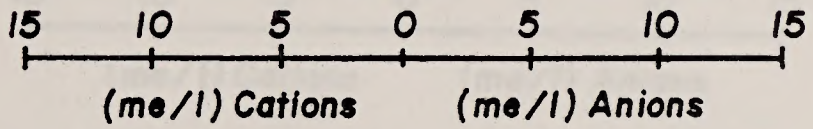
10/25/74 - 2/11/75, 7/1/75



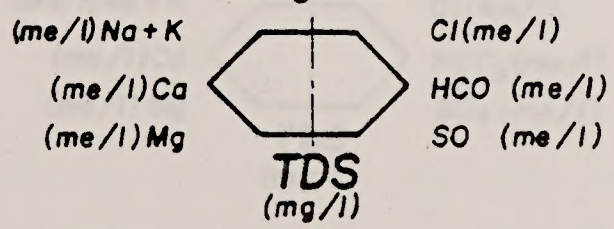
-2.7%

1114

Scale



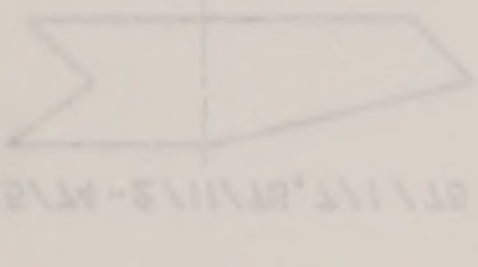
Legend



00% = PERCENT WHICH ANIONS EXCEED CATIONS

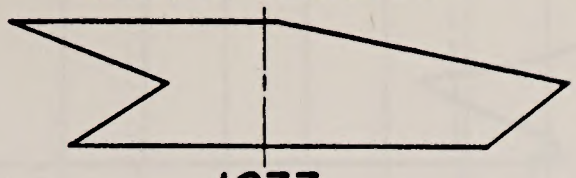
BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
PICEANCE CREEK NEAR THE WHITE RIVER
(STATION NO. 09306210)

APPENDIX D
FIGURE 7


Bottom
Middle
Top

Runoff

3/28/74 - 6/10/74

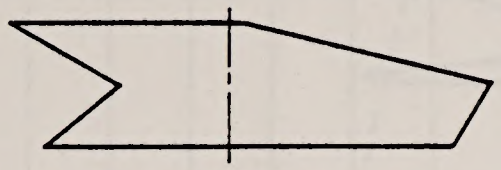


-1.3%

1233

Baseflow

10/4/73 - 2/14/74, 7/3/74 - 9/25/74

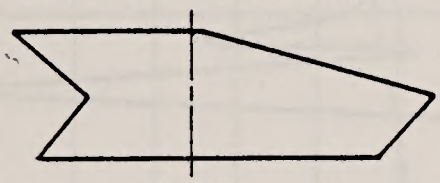


-3.1%

1150

Runoff

3/1/75 - 6/12/75

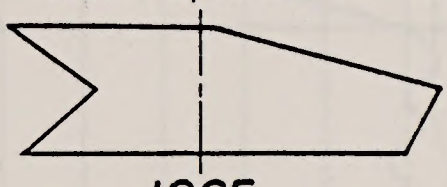


-3.1%

997

Baseflow

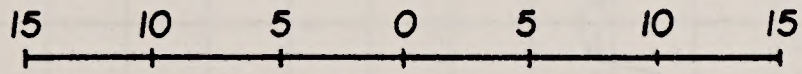
10/25/74 - 2/11/75, 6/30/75 - 9/25/75



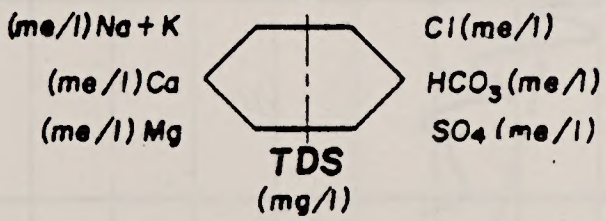
-1.5 %

1085

Scale



Legend

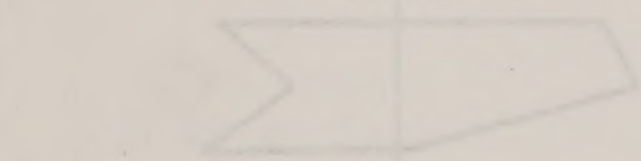


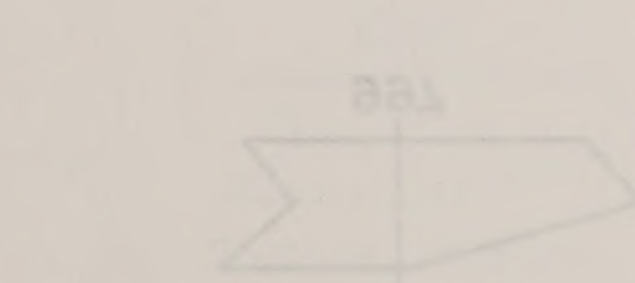
00% = PERCENT WHICH ANIONS EXCEED CATIONS

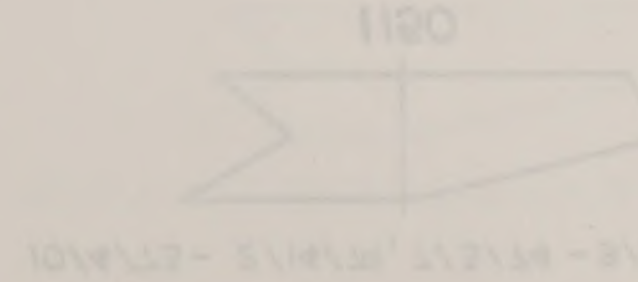
BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
PICEANCE CREEK AT THE WHITE RIVER
(STATION NO. 09306200)

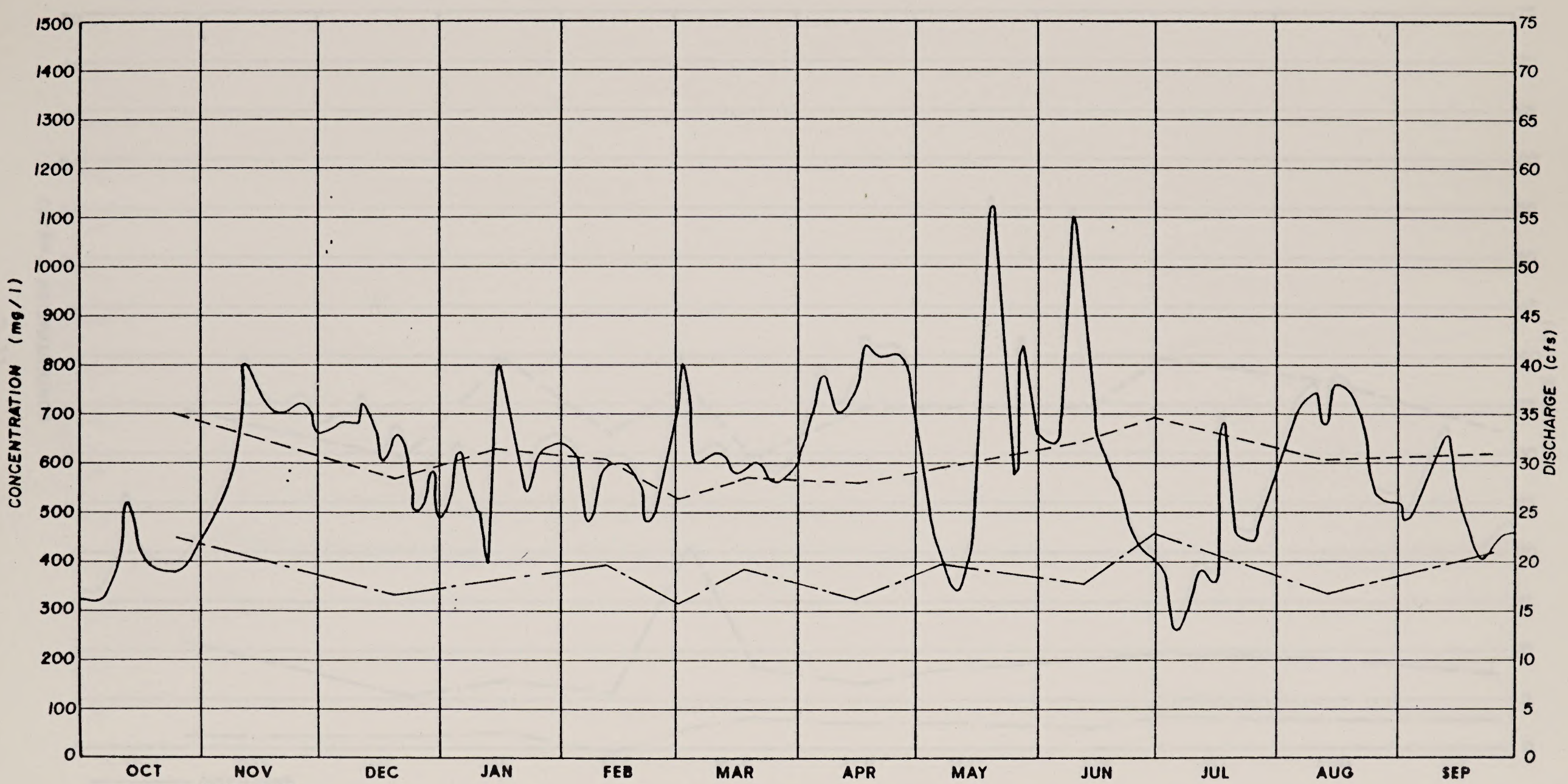
APPENDIX D

FIGURE 8



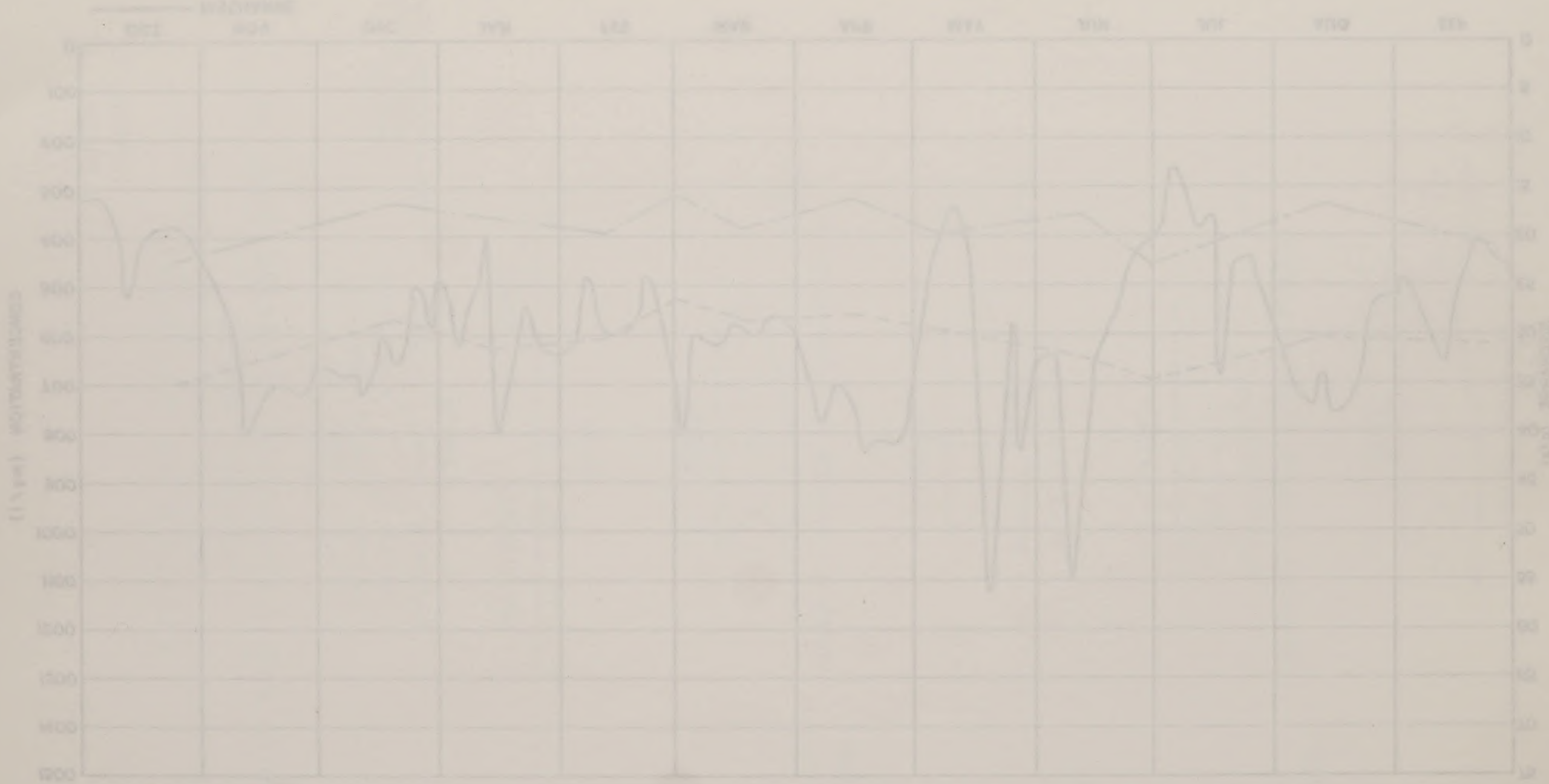


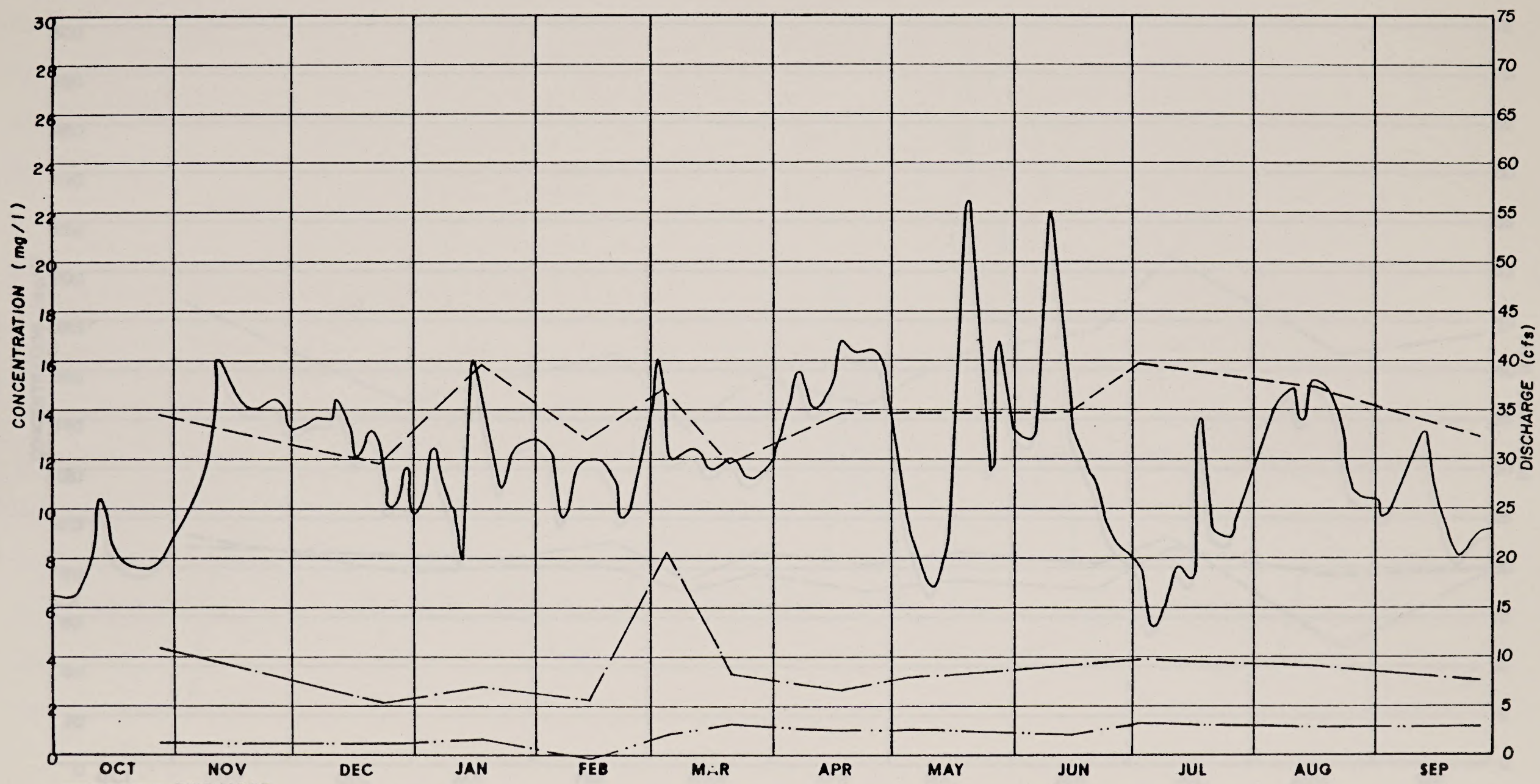




GENERAL WATER QUALITY vs. DISCHARGE
PICEANCE CREEK BELOW RYAN GULCH (09306200)
OCTOBER 1974 - SEPTEMBER 1975
SOURCE: USGS

APPENDIX D
FIGURE 9





GENERAL WATER QUALITY vs. DISCHARGE

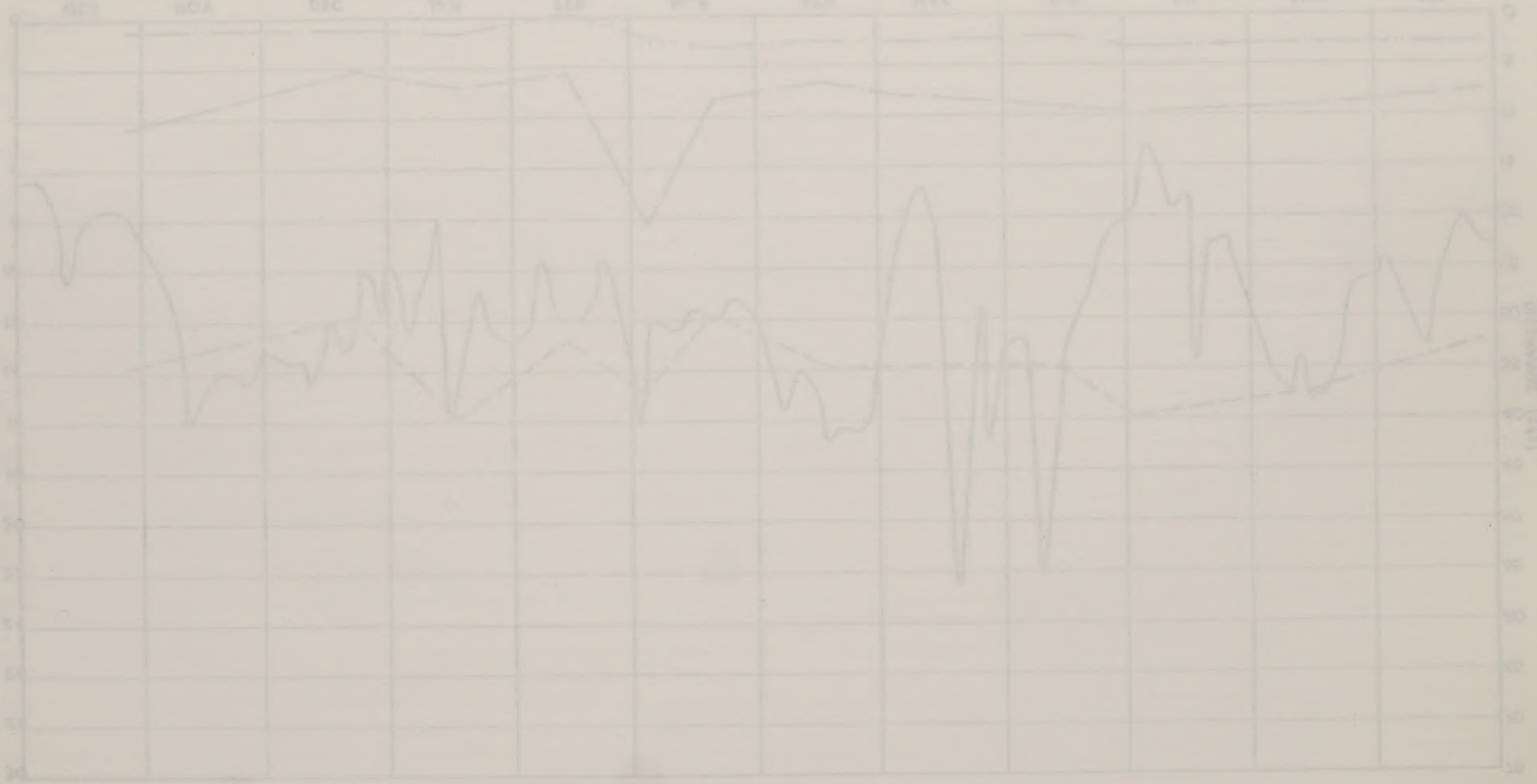
PICEANCE CREEK BELOW RYAN GULCH (09306200)

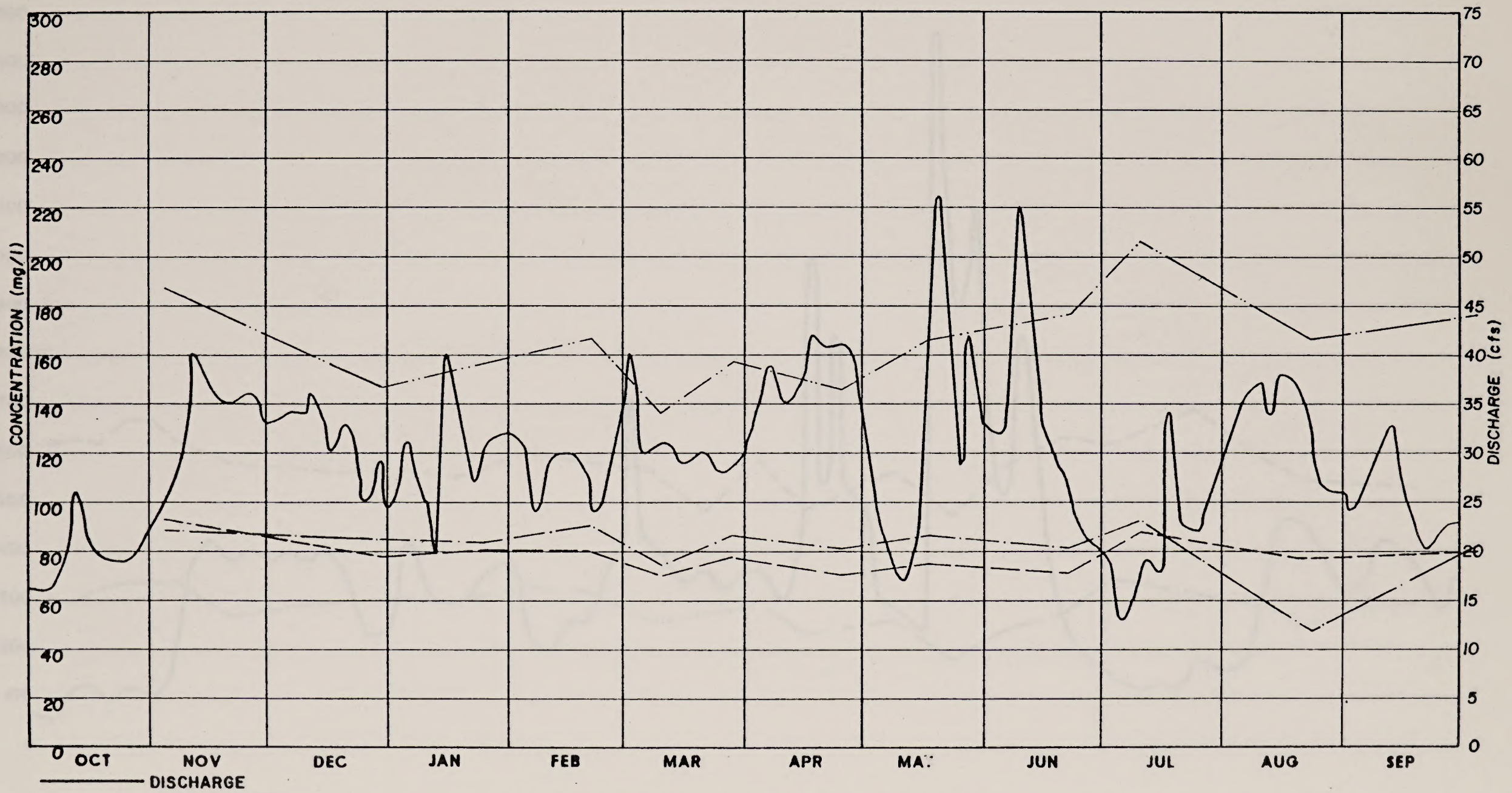
OCTOBER 1974 - SEPTEMBER 1975

SOURCE: USGS

APPENDIX D

FIGURE 10





GENERAL WATER QUALITY vs. DISCHARGE

PICEANCE CREEK BELOW RYAN GULCH (09306200)

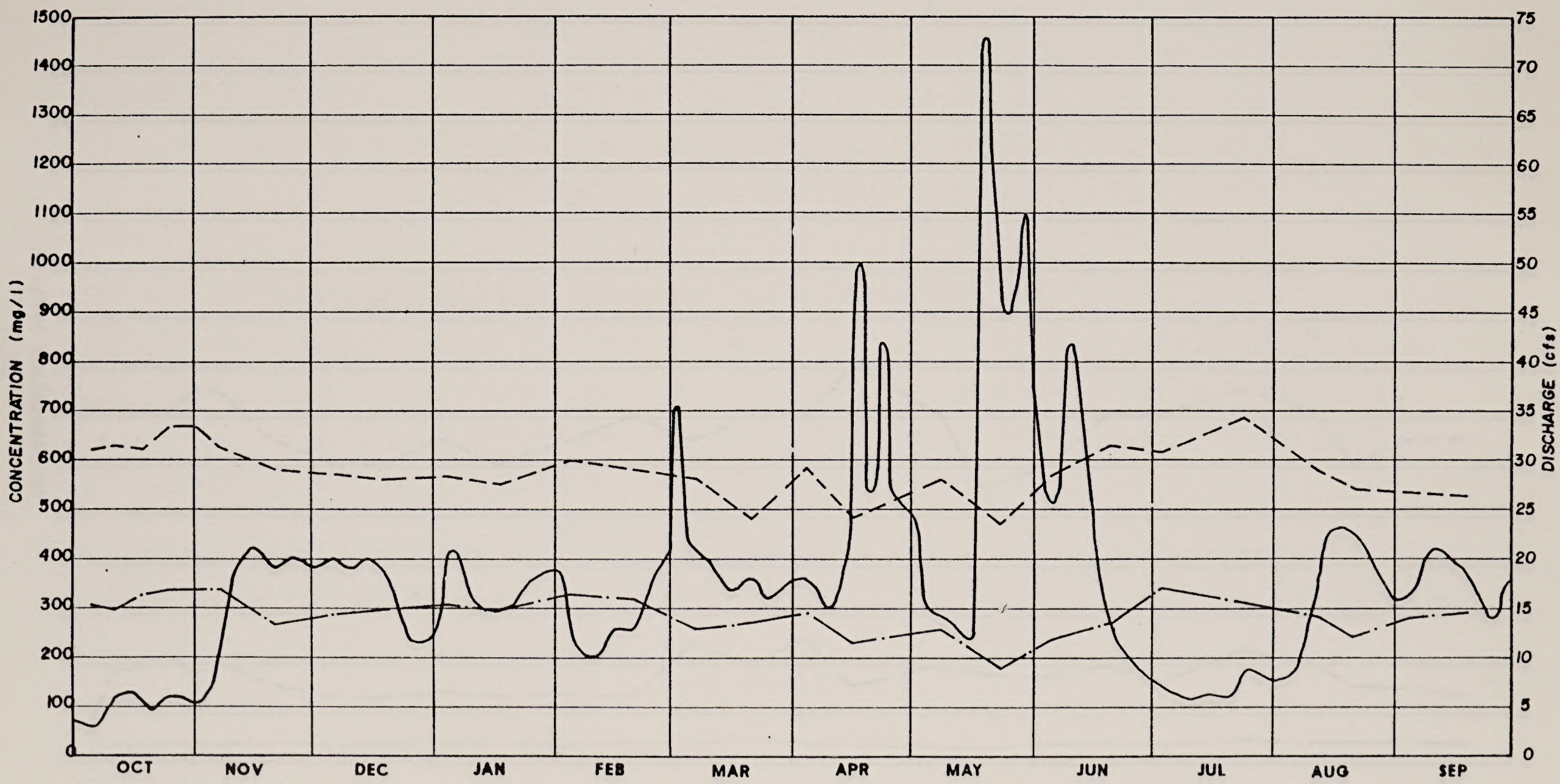
OCTOBER 1974 - SEPTEMBER 1975

SOURCE: USGS

APPENDIX D

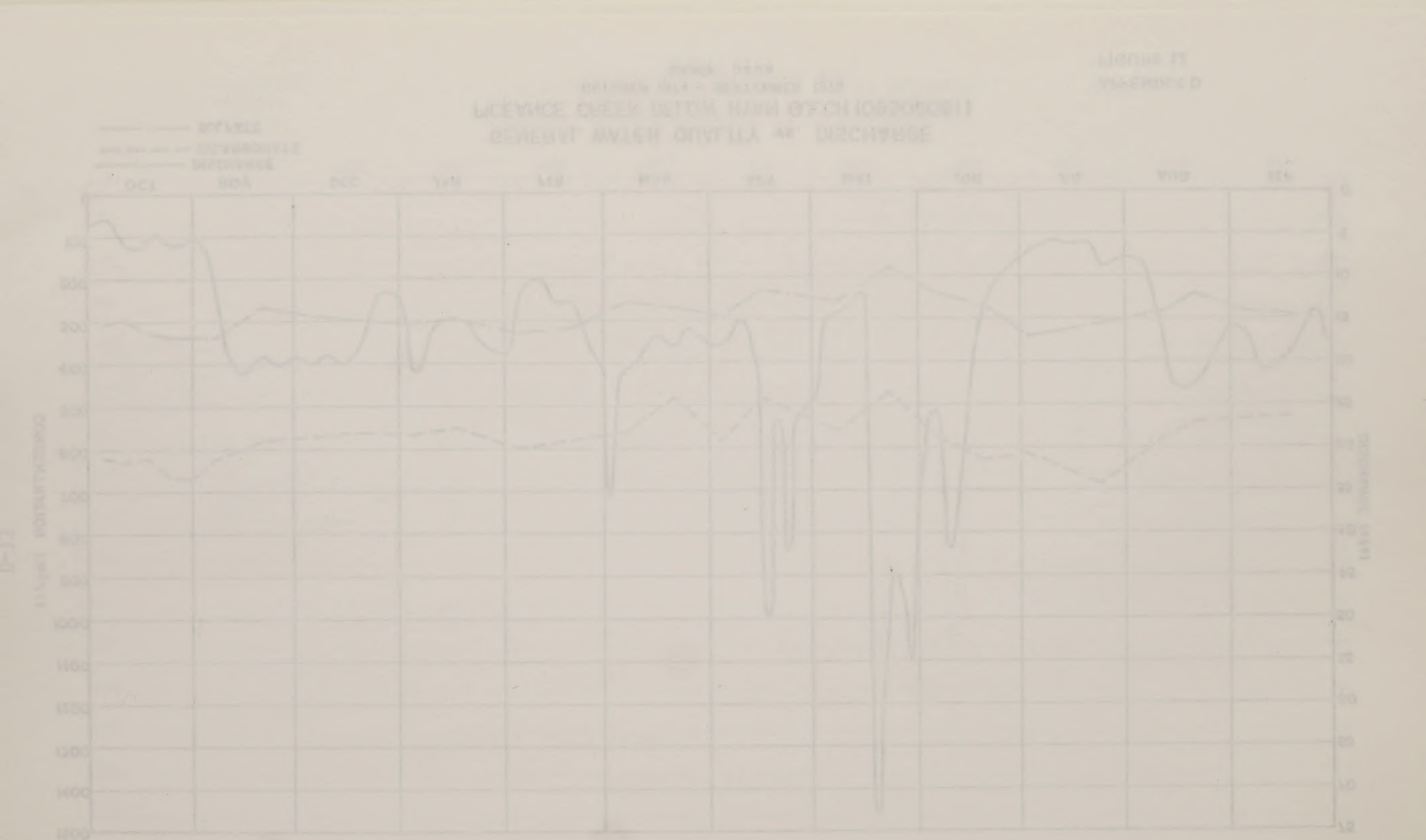
FIGURE 11

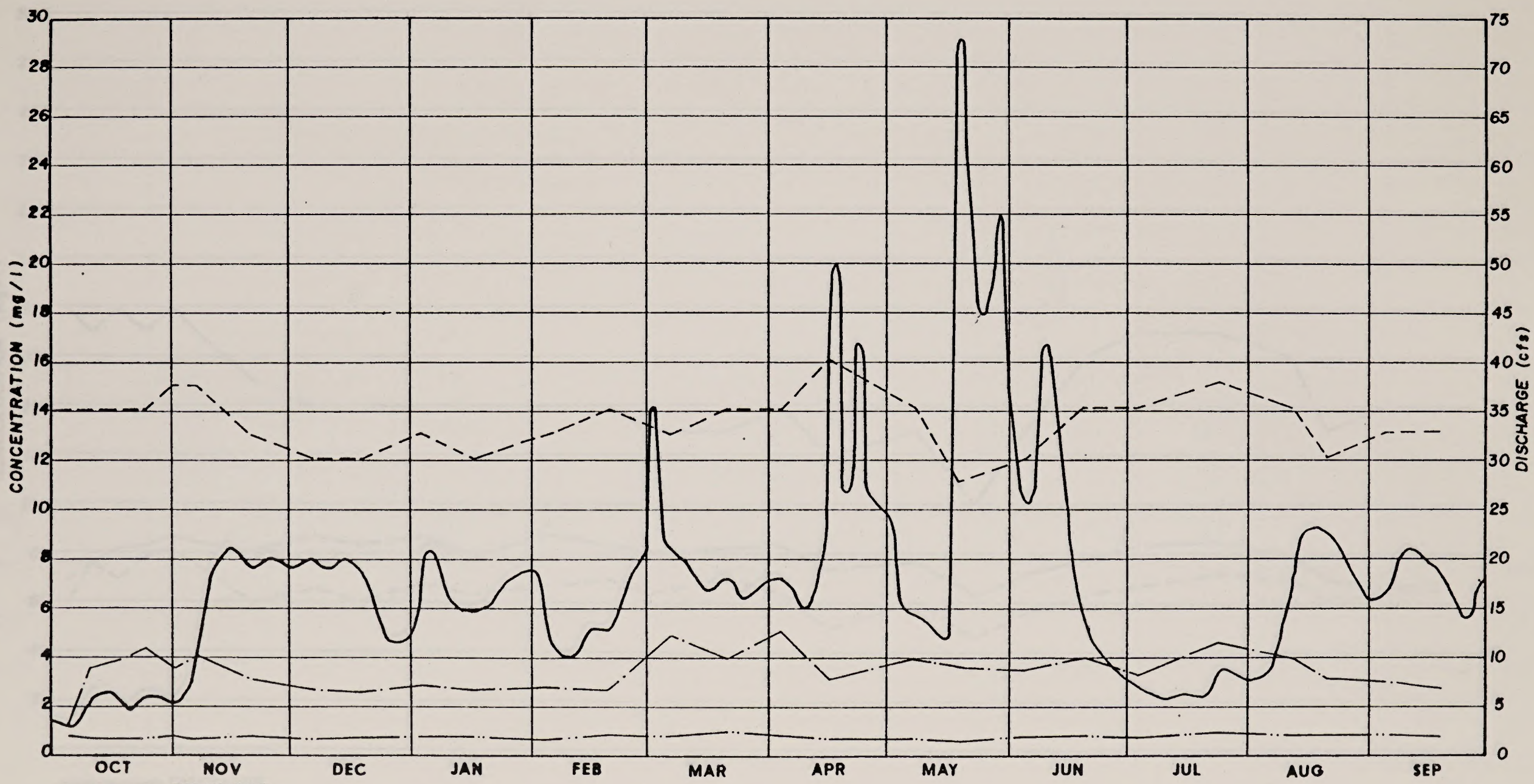




GENERAL WATER QUALITY vs. DISCHARGE
PICEANCE CREEK BELOW RYAN GULCH (09306061)
OCTOBER 1974 – SEPTEMBER 1975
SOURCE: USGS

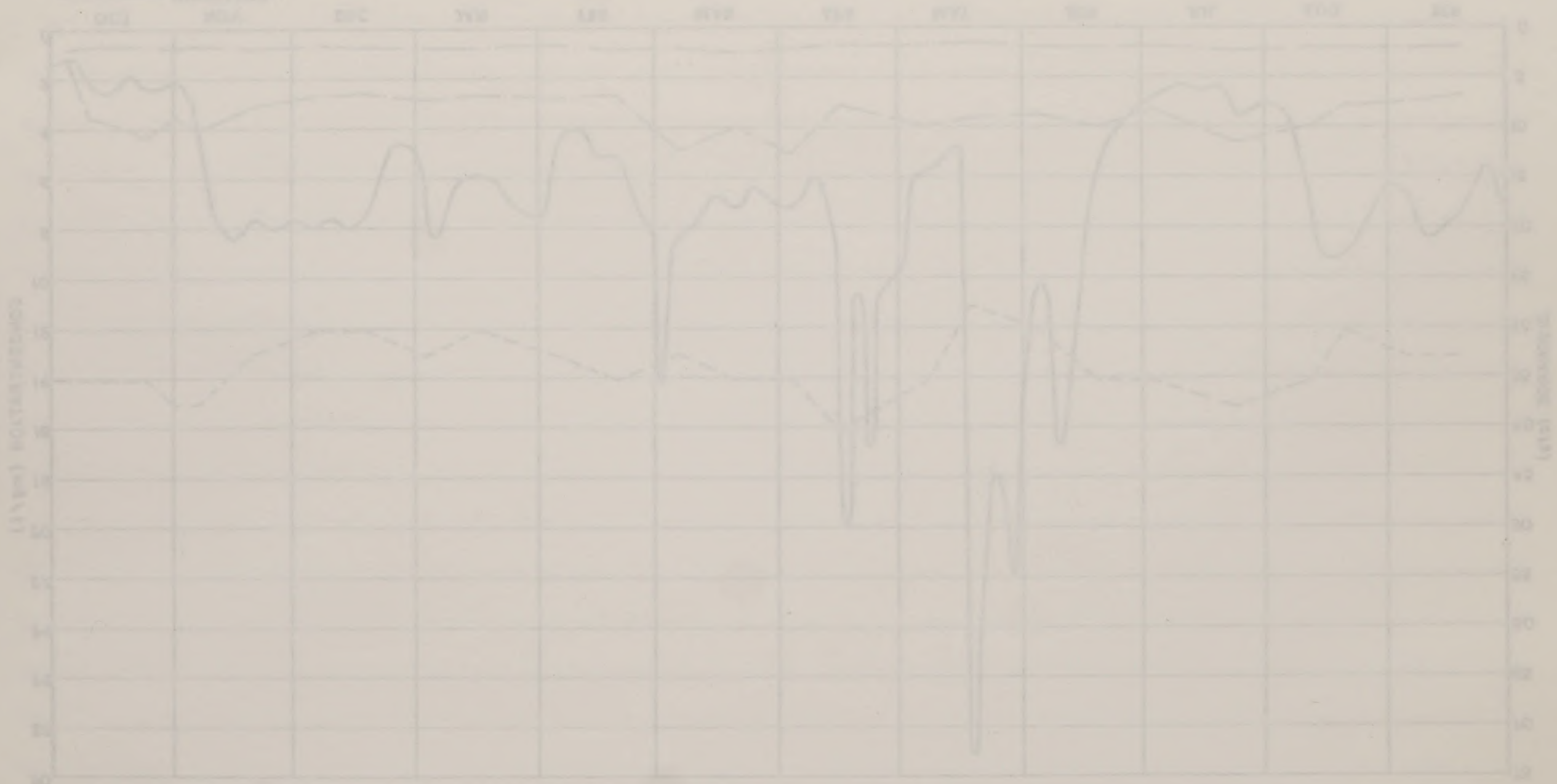
APPENDIX D
FIGURE 12

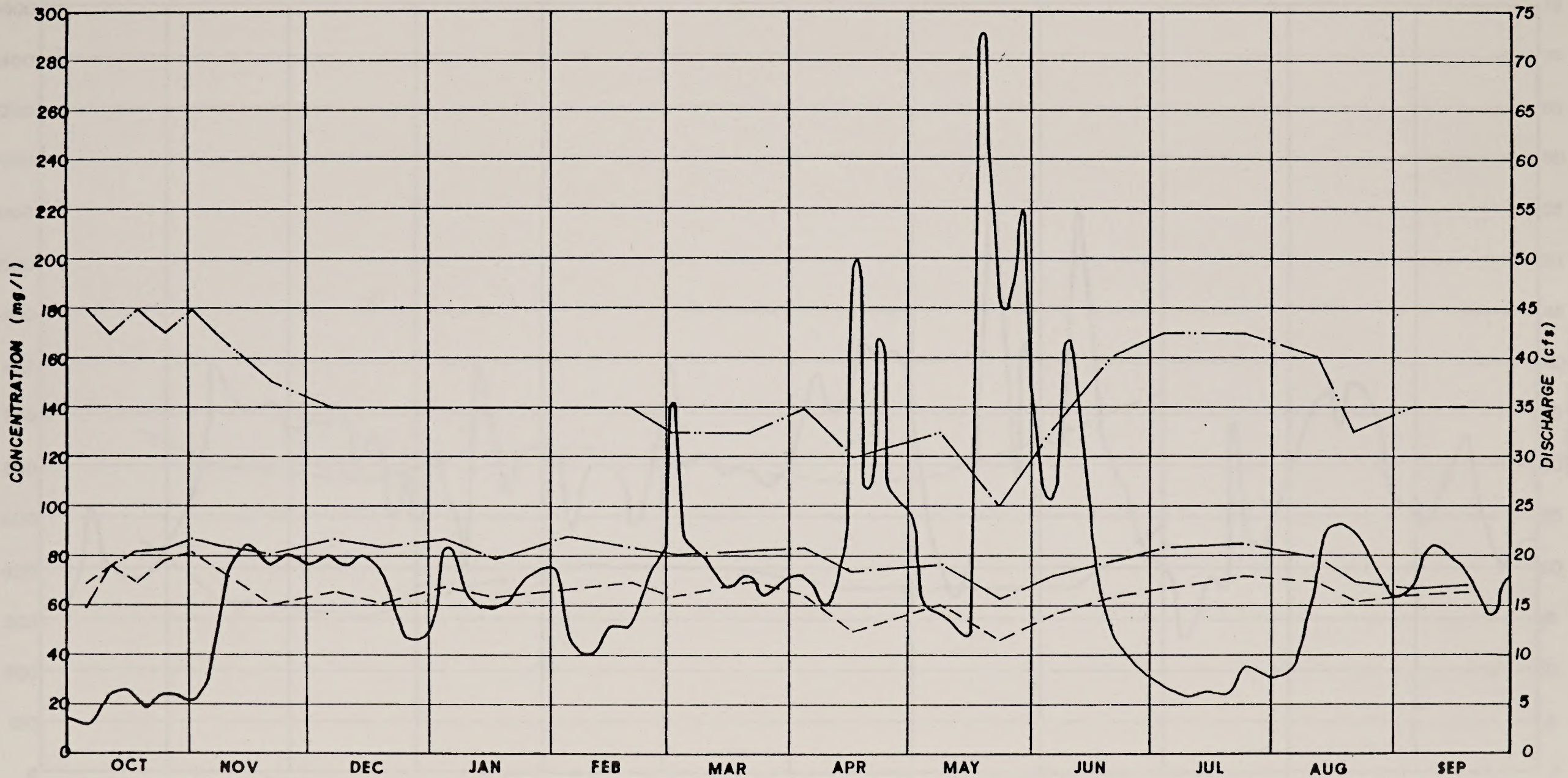




GENERAL WATER QUALITY vs. DISCHARGE
PICEANCE CREEK BELOW RYAN GULCH (09306061)
OCTOBER 1974 – SEPTEMBER 1975
SOURCE: USGS

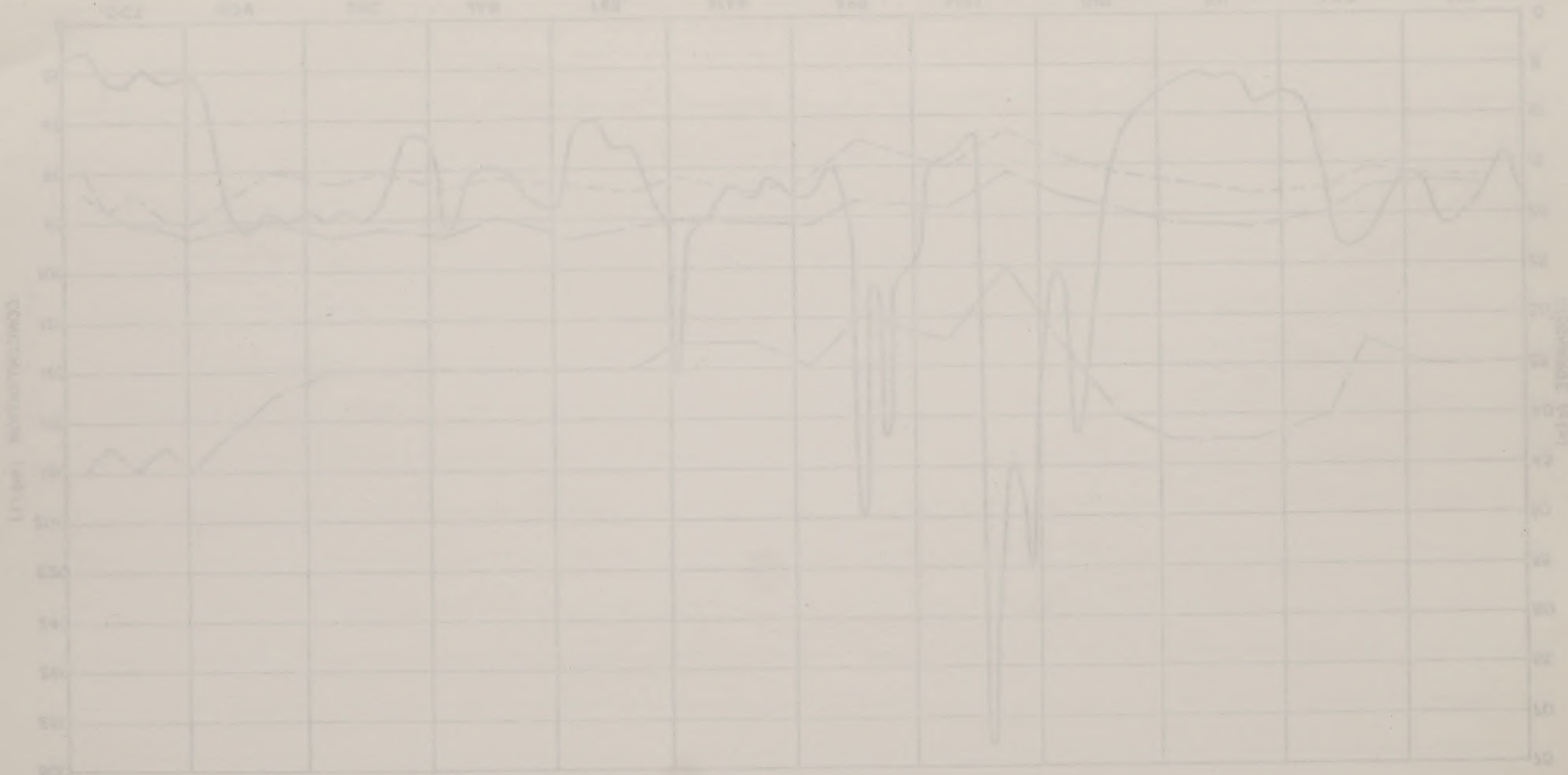
APPENDIX D
FIGURE 13

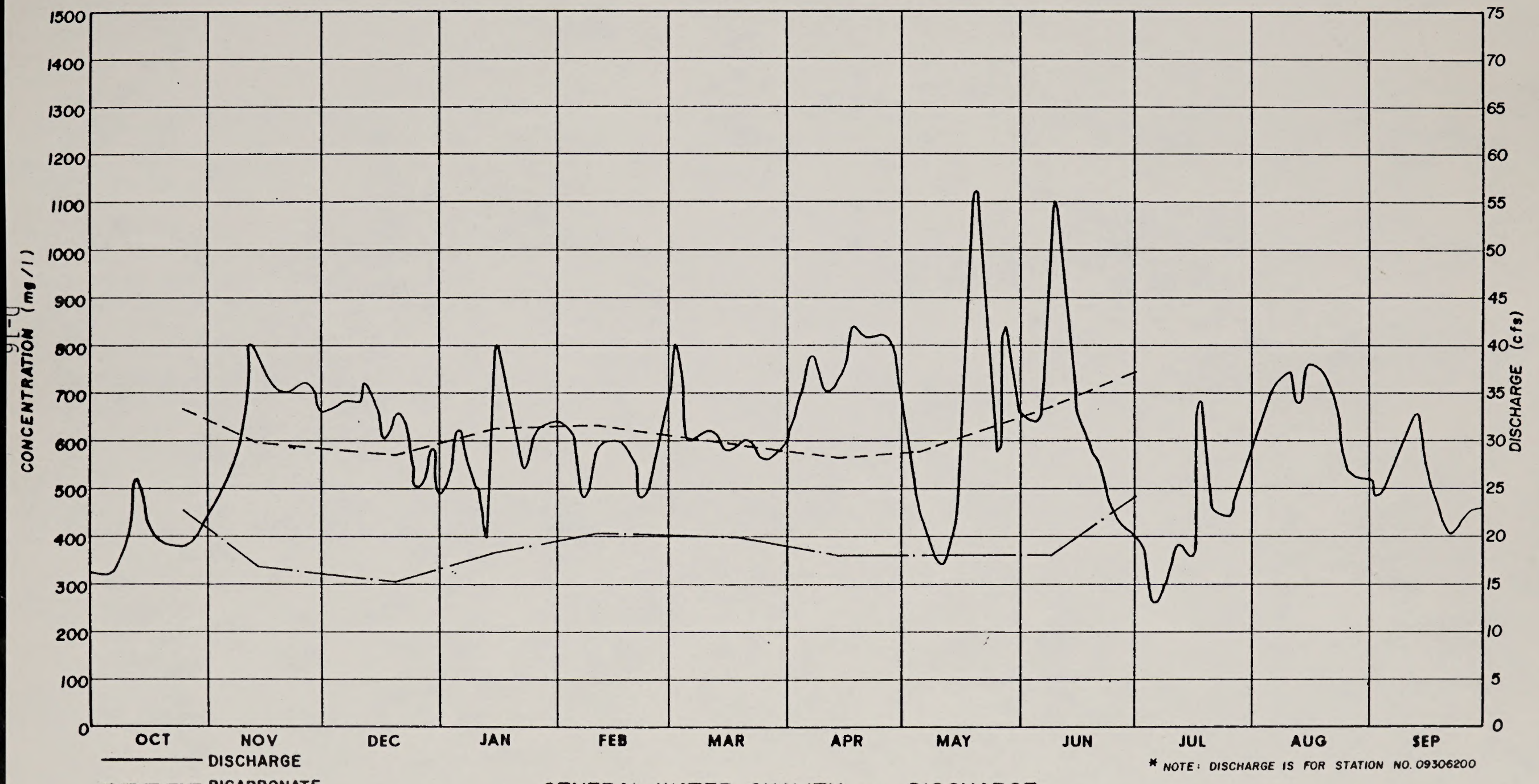




GENERAL WATER QUALITY vs. DISCHARGE
PICEANCE CREEK BELOW RYAN GULCH (09306061)
OCTOBER 1974 - SEPTEMBER 1975
SOURCE: USGS

APPENDIX D
FIGURE 14

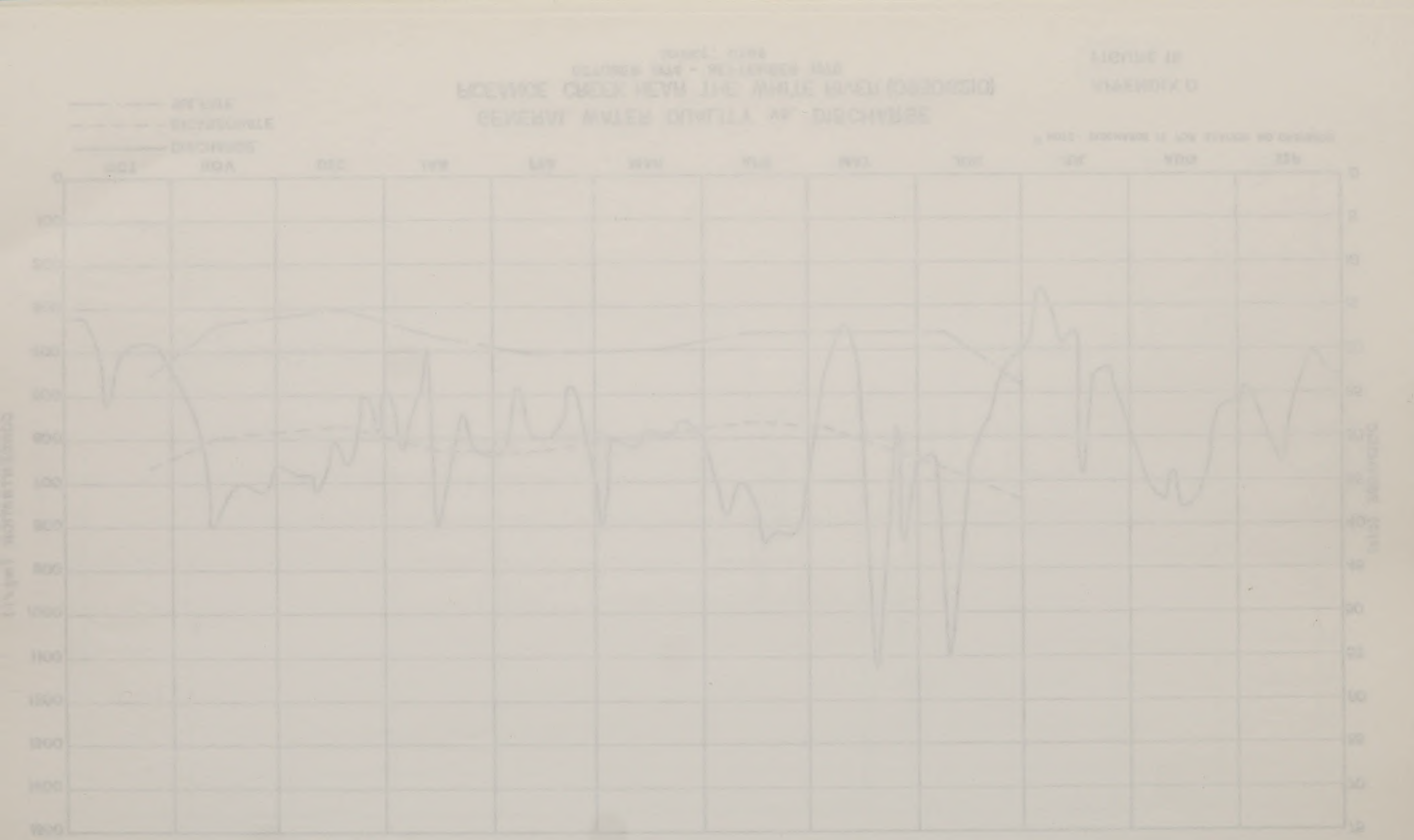




* NOTE: DISCHARGE IS FOR STATION NO. 09306200

GENERAL WATER QUALITY vs. DISCHARGE
PICEANCE CREEK NEAR THE WHITE RIVER (09306210)
OCTOBER 1974 - SEPTEMBER 1975
SOURCE: USGS

APPENDIX D
FIGURE 15



APPENDIX E

GROUND WATER HYDROLOGY

APPENDIX E

Important chemical reactions associated with oil shale leaching occur at temperatures above 600°C (pyrolysis of kerogen will be in the 650°C to 850°C thermal front), where some shale minerals are changed from their natural state into different species. The major reactions are the decomposition of the carbonates (above 600°C), principally those of magnesium and calcium, and the formation of silicates (Campbell, 1978) above 800°C. Metal oxides formed between 600°C and 800°C are hydrated to strongly alkaline hydroxides. The highest concentration of most inorganic constituents may be found in leachate derived from spent (in-place) shale produced at temperatures between 600°C-800°C. This phenomenon is primarily attributable to carbonate decomposition which occurs at temperatures above 600°C. Carbonate decomposition results in large amounts of calcium and magnesium oxides, both of which are very soluble and produce high pH leachates. If temperatures higher than 800°C exist, mineralogical reactions may form insoluble minerals which could trap leachable constituents.

Basically, three principal carbonate/silicate reactions occur during pyrolysis:

1. Dolomite ($Ca\ (Mg_x\ Fe_{1-x})\ (CO_3)_2$ decomposes at 600°C, to produce iron and magnesium oxides and calcite ($CaCO_3$).

2. Between 700°C and 800°C, calcite decomposes to calcium oxide and carbon dioxide.

3. The calcium oxide reacts with silica to produce calcium silicate compounds that are non-reactive ($3\ CaO \cdot SiO_2$, $2CaO \cdot SiO_2$).

Above 800°C nonreactive silicates form. The reactions are summarized:

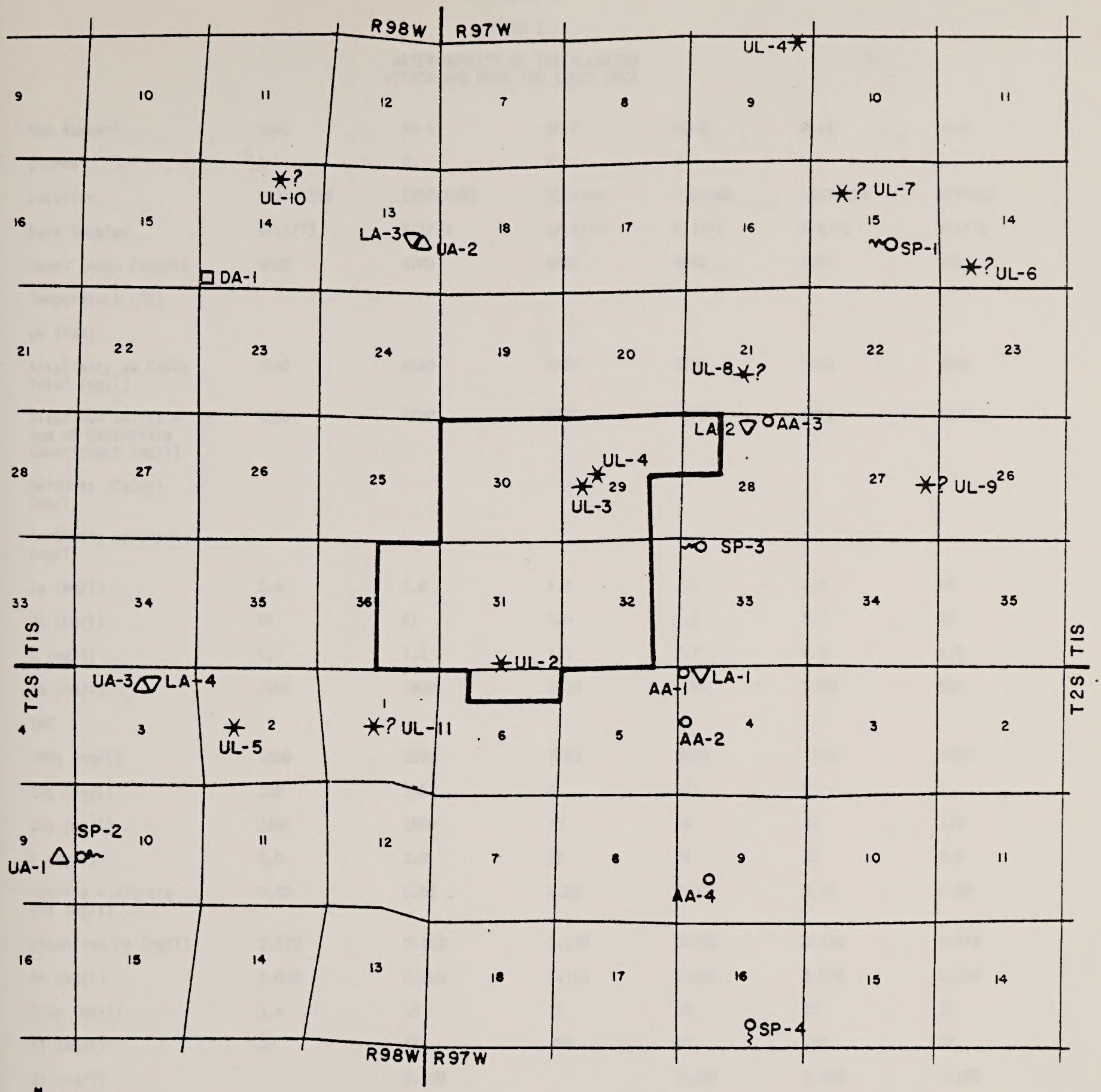
1. $Ca(Mg_x\ Fe_{1-x})\ (CO_3)_2 \longrightarrow Fe_2O_3 + MgO + CaCO_3 + CO_2$

2. $CaCO_3 \longrightarrow CaO + CO_2$

3. $CaO + SiO_2 \longrightarrow CA_xSi_yO_{(x+2y)} + CO_2$

Reactions (1-3) are greatly accelerated in the presence of steam should it occur (Campbell, 1978).

Silicate formation at high temperatures may have a significant influence on the leaching potential of shales. Silicates are relatively insoluble, suggesting that the leaching potential of shale will be significatly reduced if they are produced at temperatures greater than 800°C. This effect (Smith, 1978) may be a significant deterrent to solubilization of many constitutents.

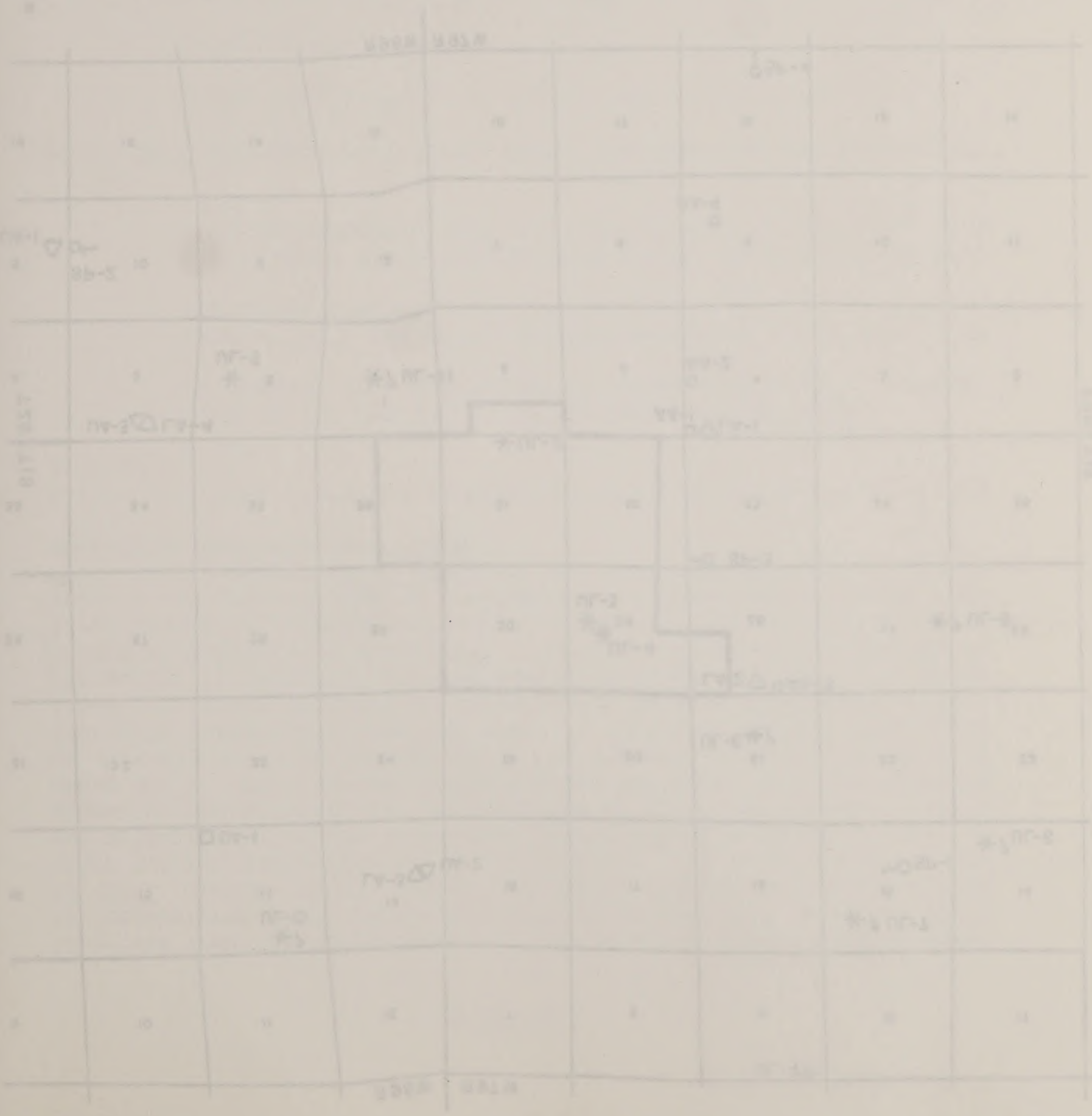


Legend

- ALLUVIAL WELL
- SPRING
- UPPER AQUIFER WELL
- LOWER AQUIFER WELL
- UPPER AND LOWER AQUIFER WELL
- AQUIFER NOT CERTAIN BUT BELIEVED TO BE UPPER AND LOWER AQUIFER WELL
- DOUGLAS CREEK AQUIFER WELL

GROUND WATER MONITORING WELLS
WITHIN AND NEAR THE STUDY AREA

APPENDIX E
FIGURE 1



APPENDIX E

TABLE 1

WATER QUALITY OF THE ALLUVIUM
WITHIN AND NEAR THE STUDY AREA

Map Number[1]	AA-1	AA-1	AA-2	AA-2	AA-3	AA-4
Source	2	2	2	2	2	2
Location	2S97W4BBB	2S97W4BBB	2S97W4B	2S97W4B	1S97W28A	2S97W9C
Date Sampled	5/11/73	8/3/73	5/11/73	8/3/73	9/6/73	8/3/73
Spec. Cond. (µmhos)	5600	6000	9590	4880	8800	2650
Temperature (°C)						
pH (lab)						
Alkalinity as $CaCO_3$ Total (mg/l)	1840	2040	5870	3590	5860	1540
Dissolved Solids - Sum of Determined Constituent (mg/l)	4300	4390	6760	4070	6720	1830
Hardness ($CaCO_3$) (mg/l)						
Carbonate Hardness (mg/l)						
Ca (mg/l)	2.4	2.8	6.8	2.9	2.4	18
Mg (mg/l)	26	81	8.5	3.6	8.3	34
K (mg/l)	1.1	1.5	4.3	2.7	4.6	1.9
Na (mg/l)	1500	1500	2900	1700	2900	680
SAR						
HCO_3 (mg/l)	1660	2200	7160	3560	7140	1880
CO_3 (mg/l)	288	142	0	401	0	0
SO_4 (mg/l)	1600	1500	70	58	41	100
F (mg/l)	2.0	2.0	28	26	33	9.8
Nitrite + Nitrate (N) (mg/l)	0.02	0.02	0.02	0.00	0.21	0.00
Dissolved Fe (mg/l)	0.530	0.110	0.140	0.050	0.240	0.060
Mn (mg/l)	0.030	0.020	0.110	0.020	0.030	0.050
SiO_2 (mg/l)	1.4	10	12	18	13	23
Cl (mg/l)	62	59	200	98	190	39
Br (mg/l)		0.400		0.300	0.300	0.100
Dis Ortho P (mg/l)	0.01	0.82	0.14	0.28	0.02	0.16
Dis As (µg/l)		26		14	1	14
Dis B (µg/l)		1300		1200	2600	820
Dis Se (µg/l)		9		7	4	3
Dis Al (µg/l)		180		10	30	370
Total Ba (µg/l)		0		100	5900	0
Total Pb (µg/l)		50		100	450	<50
Total Li (µg/l)		20		140	270	70
Total Mo (µg/l)		20		2		1
Total Sr (µg/l)		1400		370	3000	1100

[1]Locations shown on Figure 1
[2]Weeks and Welder, 1974

APPENDIX E

TABLE 1
(Continued)

WATER QUALITY OF SPRINGS
NEAR THE STUDY AREA

Map Number[1]	SP-1	SP-2	SP-3	SP-4
Source	2	2	3	3
Location	1S97W15DB	2S98W10DB	1S97W33BB	2S97W16DC
Date Sampled	10/8/65	10/8/65	6/2/73	7/16/73
Spec. Cond. (µmhos)	2120	2160	3840	1720
Temperature (°C)	10.0	9.0		
pH (lab)	8.6	7.8		
Alkalinity as $CaCO_3$ Total (mg/l)			1340	493
Dissolved Solids - Sum of Determined Constituent (mg/l)			2610	1220
Hardness ($CaCO_3$) (mg/l)	312	804		
Noncarbonate Hardness (mg/l)	0	235		
Ca (mg/l)	32	104	31	110
Mg (mg/l)	56	132	120	100
K (mg/l)			2.0	2.6
Na (mg/l)			760	160
SAR				
HCO_3 (mg/l)	1090	694	1630	601
CO_3 (mg/l)	49	0	0	0
SO_4 (mg/l)			820	510
F (mg/l)			2.0	0.6
Nitrite + Nitrate (N) (mg/l)			0.15	0.70
Dis Fe (mg/l)			0.590	0.020
Dis Mn (mg/l)			0.120	0
SiO_2 (mg/l)			18	21
Cl (mg/l)	44	20	46	12
Al (mg/l)			50	20
Br (mg/l)			0.300	0.060
Dis Ortho P (mg/l)			0.63	0.04
Dis As (µg/l)			21	0
Total Ba (µg/l)			800	0
Dis B (µg/l)			740	230
Total Pb (µg/l)			50	<50
Total Li (µg/l)			40	10
Total Mo (µg/l)			8	
Dis Se (µg/l)				0
Total Sr (µg/l)			4600	4100

[1]Locations shown on Figure 1
[2]Coffin, et al., 1968
[3]Weeks and Welder, 1974

APPENDIX E

TABLE 2

WATER QUALITY OF THE UPPER AQUIFER
WITHIN AND NEAR THE STUDY

Map Number[1]	UL-1	UL-1	UL-1	UL-5	UL-5	UA-1	UL-2	UL-2	UL-3	UL-3
Date Sampled	7/18/72	8/12/72	8/14/72	8/25/72	8/25/72	10/8/65	10/8/75	10/11/75	11/6/75	11/7/75
Dis Se (µg/l)	4						0	0	0	0
Dis Al (µg/l)		220	174				30	10	20	0
Total Ba (µg/l)		150	910							
Dis Ba (µg/l)							0	0	100	100
Total Pb (µg/l)		22	46							
Dis Pb (µg/l)							0	0	1	0
Total Li (µg/l)		100	50							
Dis Li (µg/l)							130	110	100	130
Total Mo (µg/l)		18	8							
Dis Mo (µg/l)		13					3	2	8	51
Dis Mg (µg/l)							0	0	0	0
Total Sr (µg/l)		2200	720							
Dis Sr (µg/l)							12000	3300	300	11000
Total Be (µg/l)		<2	<2							
Total Bi (µg/l)		0	0							
Total Cd (µg/l)		<5	<5							
Dis Cd (µg/l)							2	0	0	0
Total Cr (µg/l)		<3	<3							
Total Co (µg/l)		<5	<5							
Total Cu (µg/l)		110	70							
Dis Cu (µg/l)							8	0	0	2
Total Ga (µg/l)		<7	<17							
Total Ge (µg/l)		<14	<35							
Total Ni (µg/l)		16	14							
Total Ag (µg/l)	<1	<2								
Total Sn (µg/l)		<15	<35							
Total Ti (µg/l)		11	27							
Total V (µg/l)		<10	<25							
Dis V (µg/l)		3.7								
Total Zn (µg/l)		<100	<100							
Dis Zn (µg/l)							10	10	8	20
Total Zr (µg/l)		<5	38							
Percent Sodium						41				
Depth of Interval Open to Well (ft)	512 to 869	512 to 1080	512 to 1080	330 to 910	330 to 1091	0 to 37	160 to 260	160 to 836	188 to 501	188 to 830

[1]Locations shown on Figure 1
[2]Ficke, et al., 1974
[3]Coffin, et al., 1968
[4]Dale and Weeks, 1977

APPENDIX E

TABLE 2
(Continued)

Map Number[1]	UL-1	UL-1	UL-1	UL-5	UL-5	UA-1	UL-2	UL-2	UL-3	UL-3
Source	2	2	2	2	2	3	4	4	4	4
Location	1S97W9AAA	1S97W9AAA	1S97W9AAA	2S98W2BAC	2S98W2BAC	2S98W9DA	1S97W31CD	1S97W31CD	1S97W29BC	1S97W29BC
Date Sampled	7/18/72	8/12/72	8/14/72	8/25/72	8/25/72	10/8/65	10/8/75	10/11/75	11/6/75	11/7/75
Spec. Cond. (µmhos)	1230	1240	3130	1230	1290	2100	1900	1300	2100	1275
Temperature (°C)						9	13.5	19.0	13.0	15.5
pH (lab)						8.0	8.4	8.3	8.4	8.0
Alkalinity as $CaCO_3$ (mg/l)	481	508	1530	491	484		518	368	399	574
Dissolved Solids - Sum of Determined Constituent (mg/l)	797	790	1910	805	800	1540	1470	990	868	1190
Hardness ($CaCO_3$) (mg/l)						765	770	250	190	540
Noncarbonate Hardness (mg/l)						206	250	0	0	0
Ca (mg/l)	26	24	10	7.4	6.6	98	71	21	20	55
Mg (mg/l)	58	42	2.8	12	11	126	140	48	34	95
K (mg/l)	0.6	0.6	1.2	0.6	0.4	1.4	0.9	0.5	0.6	1.0
Na (mg/l)	190	210	770	250	290	243	230	260	230	230
SAR						3.8	3.6	7.2	7.3	4.4
HCO_3 (mg/l)	587	619	1610	564	590	682	631	449	487	700
CO_3 (mg/l)	0	0	123	17	0	0	0	0	0	0
SO_4 (mg/l)	190	170	10	150	160	703	670	410	300	420
F (mg/l)	1.4	3.1	20	12	12	0.3	0.3	1.6	0.4	4.2
Nitrate (NO_3) (mg/l)						3.4	0	0	0.03	0.11
Total Fe (mg/l)		2.6	3.4							
Dis Fe (mg/l)	0.51	2.60	1.60	4.00	0.86		0	0.60	0.01	0
Total Mn (mg/l)		0.033	0.030							
Dis Mn (mg/l)	0.01	0.04	0.03	0	0		0.05	0.01	0.006	0.17
SiO_2 (mg/l)	30	21	15	11	15	16	26	16	33	16
Cl (mg/l)	12	12	168	63	14	17	11	7.3	9.3	6.5
Br (mg/l)							0.1	0.1	0.1	0
Dis Ortho P (mg/l)							0.01	0.01	0.03	0.01
Total As (µg/l)		<46	<46							
Dis As (µg/l)							1	6	2	3
Total B (µg/l)		100	260							
Dis B (µg/l)		160				0.21	170	230	200	150

APPENDIX E

TABLE 3

WATER QUALITY OF THE LOWER AQUIFER
WITHIN AND NEAR THE STUDY AREA

Map Number[1]	LA-1	LA-2	UL-5	UL-5
Source	2	3	4	4
Location	2S97W4BBB	1S97W28AB	2S98W2BAC	2S98W2BAC
Date Sampled	6/21/73	10/12/64	8/25/72	8/28/72
Spec. Cond. (µmhos)	14800	20700	1310	1400
Temperature (°C)		21		
pH (lab)		8.7		
Alkalinity as $CaCO_3$ Total (mg/l)	10400		500	548
Dissolved Solids - Sum of Determined Constituent (mg/l)	11500	17400	824	833
Hardness ($CaCO_3$) (mg/l)		40		
Noncarbonate Hardness (mg/l)		0		
Ca (mg/l)	13	0.0	14	11
Mg (mg/l)	26	9.5	10	8.5
K (mg/l)	7.2	19	0.4	0.5
Na (mg/l)	4800	7540	300	310
SAR		522		
HCO_3 (mg/l)	12700	9880	610	668
CO_3 (mg/l)	0	4320	0	0
SO_4 (mg/l)	64	15	160	140
F (mg/l)	18	30	12	13
Nitrate NO_3 (mg/l)		2.3		
Fe (mg/l)		0.04	1.100	0.260
Mn (mg/l)	20		0.020	0.020
SiO_2 (mg/l)	12	12	13	2.7
Cl (mg/l)	290	542	14	18
Br (mg/l)	0.400			
Dis Ortho P (mg/l)	.61			
Dis As (µg/l)	2			
Dis B (µg/l)	2600	2600		
Dis Se (µg/l)	0			
Percent Sodium		100		
Sample Depth Interval	64 ft to 2235 ft			
Depth of Interval Open to Well		0 to 3051 ft	1051 to 1560 ft	1050 to 1560 ft

[1]Locations shown on Figure 1
[2]Weeks and Welder, 1974
[3]Coffin, et al., 1968
[4]Ficke, et al., 1974

APPENDIX E

TABLE 3
(Continued)

WATER QUALITY FOR WELLS OPEN TO THE
UPPER AND LOWER AQUIFERS WITHIN AND NEAR THE STUDY AREA

Map Number[1]	UL-1	UL-1	UL-2	UL-2	UL-2	UL-2	UL-2
Source	2	2	3	3	3	3	3
Location	1S97W9AAA	1S97W9AAA	1S97W31CD	1S97W31CD	1S97W31CD	1S97W31CD	1S97W31CD
Date Sampled	11/4/71	8/12/72	10/16/75	10/18/75	10/20/75	10/24/75	10/28/75
Spec. Cond. (µmhos)	12400	5580	1320	3500	5900	9000	11200
Temperature (°C)			18.0	20.0	20.0	20.0	20.5
pH (lab)			8.1	8.1	8.3	8.4	8.1
Alkalinity as $CaCO_3$ Total (mg/l)	5310	1980	403	1970	3680	4270	5680
Dissolved Solids - Sum of Determined Constituent (mg/l)	7990	3530	1010	2700	4580	6140	8170
Hardness (Ca, Mg) (mg/l)			210	190	180	200	260
Noncarbonate Hardness (mg/l)			0	0	0	0	0
Ca (mg/l)	5.9	7.1	17	16	15	18	45
Mg (mg/l)	3.0	3.6	39	36	34	37	36
K (mg/l)	6.2	2.1	0.4	2.0	2.3	3.3	3.8
Na (mg/l)	3200	1500	280	1000	1800	2400	3300
SAR			8.6	32	59	74	89
HCO_3 (mg/l)	5730	1490	491	2400	4490	4620	4930
CO_3 (mg/l)	368	453	0	0	0	286	981
SO_4 (mg/l)	54	25	400	370	340	370	390
F (mg/l)	24	21	1.9	3.9	6.0	5.7	6.2
Nitrite + Nitrate (N) (mg/l)			0.01	0.02	0.00	0.01	0.01
Total Fe (mg/l)		2.000					
Dis Fe (mg/l)	.040	.500	.050	.050	.130	.420	.660
Total Mn (mg/l)		0.28					
Dis Mn (mg/l)	.010	.030	0	.010	.010	0	.020
SiO_2 (mg/l)	8.9	9.4	17	16	12	12	9.8
Cl (mg/l)	1500	770	7.0	72	150	720	960
Br (mg/l)			0	0.1	0.3	0.9	1.3
Dis Ortho P (mg/l)			0.02	0.15	0.26	0.00	0.01
Dis As (µg/l)			4	3	6	20	13
Total As (µg/l)		46					
Total B (µg/l)		290					
Dis B (µg/l)			290	630	890	1300	1600
Dis Se (µg/l)			0	0	0	0	0
Dis Mg (µg/l)			0.0	0.0	0.0	0.0	0.0
Dis Al (µg/l)		170	10	50	20	20	0
Total Ba (µg/l)		1000					

APPENDIX E

TABLE 3
(Continued)

Map Number[1]	UL-3	UL-3	UL-3	UL-3	UL-4	UL-4	UL-5	UL-5
Source	3	3	3	3	3	3	2	2
Location	1S97W29BC	1S97W29BC	1S97W29BC	1S97W29BC	1S97W29BC	1S97W29BC	2S98W2BAC	2S98W2BAC
Date Sampled	11/12/75	11/13/75	11/18/75	11/22/75	12/19/75	1/8/76	8/25/72	8/25/72
Spec. Cond. (µmhos)	1400	1800	4800		1200	1600	1480	1330
Temperature (°C)	18.0	18.5	18.0	18.0	15.0	15.0		
pH (lab)	8.1	8.2	8.0	8.1	7.8	8.3		
Alkalinity as $CaCO_3$ Total (mg/l)	640	837	943	1600	501	813	566	509
Dissolved Solids - Sum of Determined Constituent (mg/l)	962	1170	2140	6020	991	1060	899	851
Hardness (Ca, Mg) (mg/l)	120	110	87	72	240	44		
Noncarbonate Hardness (mg/l)	0	0	0	0	0	0		
Ca (mg/l)	14	12	9.3	8.5	27	5.8	9.1	5.9
Mg (mg/l)	19	19	15	12	42	6.9	11	8.3
K (mg/l)	0.7	0.6	0.7	1.2	1.6	2.5	0.6	0.4
Na (mg/l)	340	430	820	2400	270	410	300	330
SAR	14	18	39	124	7.6	27		
HCO_3 (mg/l)	780	1020	1150	1950	550	991	660	610
CO_3 (mg/l)	0	0	0	0	30	0	15	5
SO_4 (mg/l)	170	170	140	110	310	110	180	160
F (mg/l)	7.6	1.0	1.0	8.9	4.8	10	13	13
Nitrite + Nitrate (N) (mg/l)	0.08	0.03	0.18	0.08	0.06	0.07		
Total Fe (mg/l)								
Dis Fe (mg/l)	.010	.020	0	.070	0	0.250	0.380	0.480
Total Mn (mg/l)								
Dis Mn (mg/l)	.020	.010	.020	.005	0.020	0.020	0.020	0.020
SiO_2 (mg/l)	12	12	15	10	17	8.6	15	13
Cl (mg/l)	11	21	570	2500	12	13	30	15
Br (mg/l)	0.1	0.1	0.9	4.0	0.1	0.1		
Dis Ortho P (mg/l)	0.02	0.04	0.06	0.04	0.30	1.5		
Dis As (µg/l)	14	14	14	17	14	9		
Total As (µg/l)								
Total B (µg/l)								
Dis B (µg/l)	160	320	400	460	200	290		270
Dis Se (µg/l)	0	0	1	0	0	0		
Dis Mg (µg/l)	0.0	0.0	0.0	0.0	1.0	0.0		
Dis Al (µg/l)	20	20	30	20	20	40		
Total Ba (µg/l)								

APPENDIX E

TABLE 3
(Continued)

Map Number[1]	UL-1	UL-1	UL-2	UL-2	UL-2	UL-2	UL-2
Date Sampled	11/4/71	8/12/72	10/16/75	10/18/75	10/20/75	10/24/75	10/28/75
Dis Ba (µg/l)			0	300	400	500	600
Total Pb (µg/l)		9					
Dis Pb (µg/l)			3	2	2	8	4
Total Li (µg/l)		170					
Dis Li (µg/l)			100	170	250	250	270
Total Mo (µg/l)		69					
Dis Mo (µg/l)			1	2	5	66	50
Total Sr (µg/l)		1200					
Dis Sr (µg/l)			2500	2500	2200	2500	2300
Total Be (µg/l)		<2					
Total Bi (µg/l)		0					
Total Cd (µg/l)		<5					
Dis Cd (µg/l)			0	0	0	2	0
Total Cr (µg/l)		<3					
Total Co (µg/l)		<5					
Total Cu (µg/l)		23					
Dis Cu (µg/l)			0	0	0	0	0
Total Ga (µg/l)		<20					
Total Ge (µg/l)		<45					
Total Ni (µg/l)		14					
Total Ag (µg/l)		<2					
Total Sn (µg/l)		<45					
Total Ti (µg/l)		<11					
Total V (µg/l)		<30					
Total Zn (µg/l)		<100					
Dis Zn (µg/l)			10	30	7	10	10
Total Zr (µg/l)		28					
Depth of Interval Open to Well (ft)	520 to 2129	512 to 1380	160 to 1053	160 to 1207	160 to 1420	160 to 1967	160 to 2382

[1]Locations shown on Figure 1
[2]Ficke, et al., 1974
[3]Dale and Weeks, 1977

APPENDIX E

TABLE 3
(Continued)

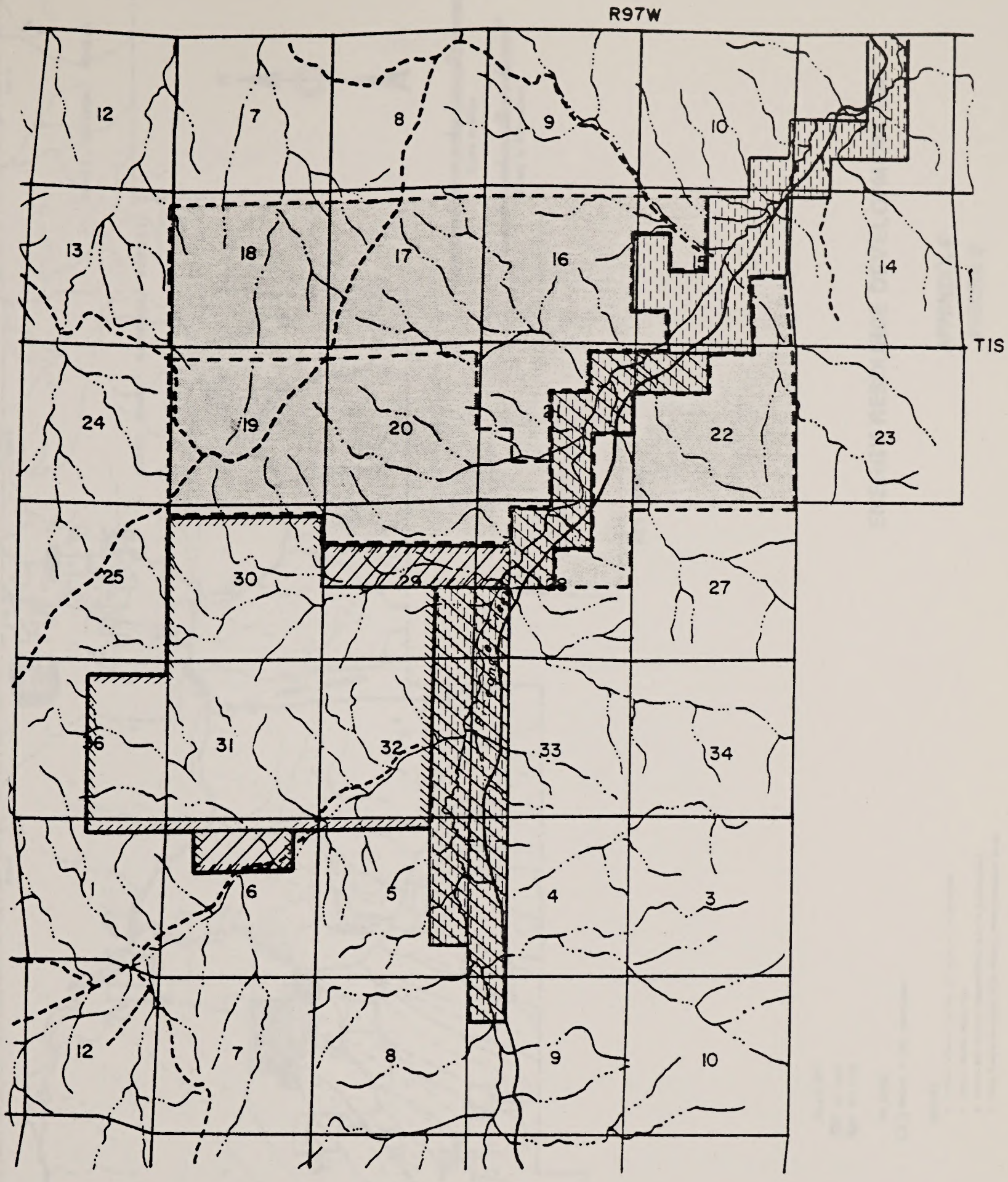
Map Number[1]	UL-3	UL-3	UL-3	UL-3	UL-4	UL-4	UL-5	UL-5
Date Sampled	11/12/75	11/13/75	11/18/75	11/22/75	12/19/75	1/8/76	8/25/72	8/25/72
Dis Ba (µg/l)	200	100	200	100	200	100	1	
Total Pb (µg/l)								
Dis Pb (µg/l)	4	2	1	5	1	1		
Total Li (µg/l)								
Dis Li (µg/l)	80	100	90	80	90	10		
Total Mo (µg/l)								
Dis Mo (µg/l)	20	24	31	15	41	11		4
Total Sr (µg/l)								
Dis Sr (µg/l)	1700	1700	1200	1100	3500	510		
Total Be (µg/l)								
Total Bi (µg/l)								
Total Cd (µg/l)								
Dis Cd (µg/l)	3	0	0	1	0	0		
Total Cr (µg/l)								
Total Co (µg/l)								
Total Cu (µg/l)								
Dis Cu (µg/l)	1	0	0	1	0	0		
Total Ga (µg/l)								
Total Ge (µg/l)								
Total Ni (µg/l)								
Total Ag (µg/l)								
Total Sn (µg/l)								
Total Ti (µg/l)								
Total V (µg/l)								
Total Zn (µg/l)								
Dis Zn (µg/l)	30	0	10	10	10	20		
Total Zr (µg/l)								
Depth of Interval Open to Well (ft)	188 to 1313	188 to 1429	188 to 2175	188 to 2547	190 to 975	844 to 1451	330 to 910	1051 to 1091

[1]Locations shown on Figure 1
[2]Ficke, et al., 1974
[3]Dale and Weeks, 1977

V

APPENDIX F

LAND USE



LEGEND

Bureau of Mines Proposal
Surface and Mining
Surface Only

Oil Shale InSitu Nomination
(Boundary coincides with
Sodium Lease Application)

All National Resource Lands are leased for oil and gas development.

National Resource Land

Private Minerals (All)

Sodium Lease Applications

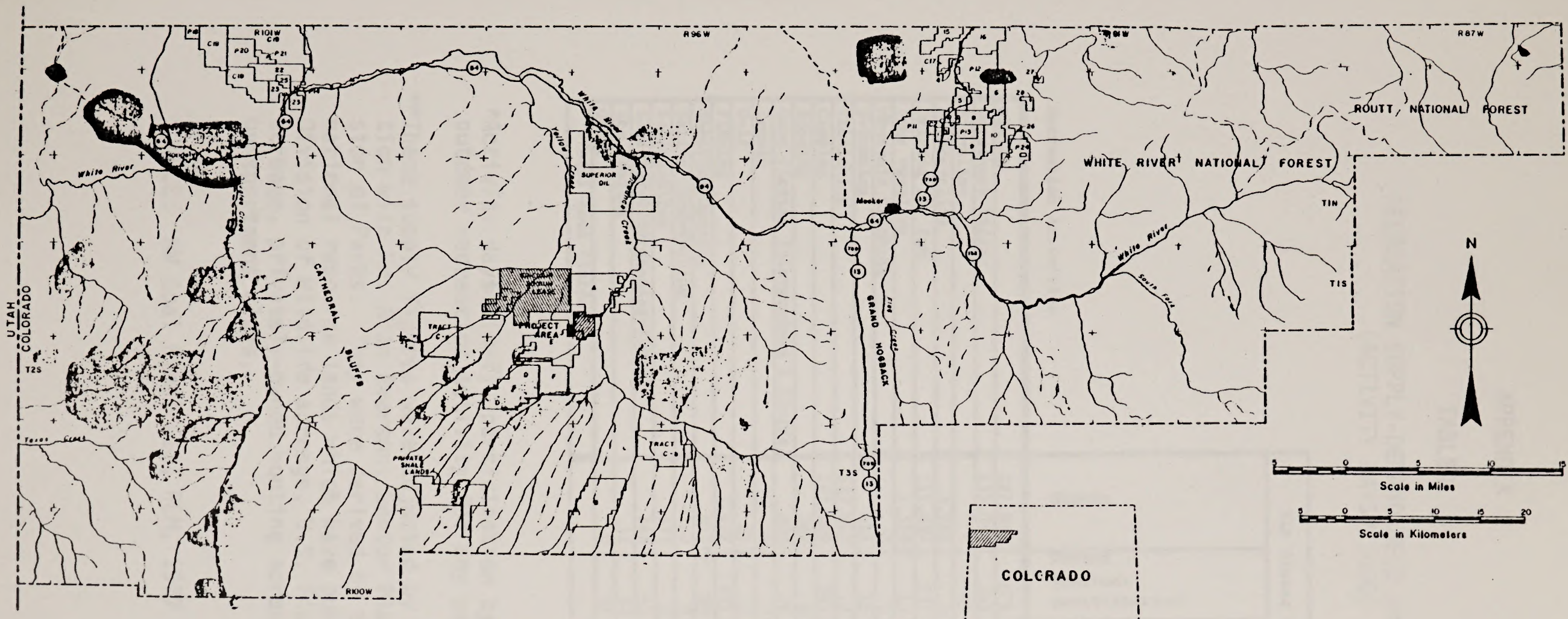
Division of Wildlife

LAND STATUS

APPENDIX F

FIGURE 1





F-3

LEGEND

FEDERAL COAL LEASES

Code numbers with a "C" prefix are competitive lease applications

Code numbers with a "D" prefix are preference right lease applications

Code #	Firm Lease Holder	Lease #
1	American Fuels Co	C-07871
C2	Commonwealth Coal Co	C-15846
3	Commonwealth Coal Co	D-044746
4	Consolidated Coal Co	C-245
5	Consolidated Coal Co	C-1546
6	Consolidated Coal Co	C-093713
7	Consolidated Coal Co	C-1545
8	Consolidated Coal Co	C-093714
9	Consolidated Coal Co	C-093715
10	Consolidated Coal Co	C-093716
P11	Ember Mining Co	C-01261997
P12	Ember Mining Co	C-01261998
P13	Ember Mining Co	C-01261999
P14	Gordon Staley Coal	C-01286460
15	James C Goodwin	C-0127926
16	James C Goodwin	C-0127827
C17	James C Goodwin	C-3440
P18	L.C. Craig	C-01253661
C19	Moon Lake Electric	C-27664
P20	Moon Lake Electric	C-8424
P21	Moon Lake Electric	C-8425
P22	Moon Lake Electric	C-027703
P23	Paul F. Biondo	C-0276875
P24	Phillip A. Jensen and E.W. Miller	C-6275
25	Pittsburg Coal Mining Co	D-047701
26	W.R. Grace	C-27837
27	W.R. Grace	C-22838
28	W.R. Grace	C-22838

OIL and GAS

Oil Field

Gas Field

OIL SHALE

A Federal In Situ Nominations

SOURCES

1. Northwest Colorado Coal Final EIS, Bureau of Land Management
2. Rangely, Colorado Master Plan
3. Piceance Basin Wildlife Management Plan, Bureau of Land Management
4. Energy Resource Development Map of Colorado, Colorado Geological Survey

ENERGY RESOURCE DEVELOPMENT MAP

APPENDIX F

FIGURE 2



APPENDIX F

TABLE 1

RECREATION SUPPLY-DEMAND-NEED ANALYSIS
(ACTIVITY DAYS*/1000)

Recreation Activities	Rio Blanco County (52)			
	Supply	Demand (current participation)	Difference	
			Activity Days (+ surplus) (- deficit)	% of total deficit for County
Hiking	227,862	178	+227,684	
Horseback Riding	135,096	345	+135,250	
Bicycling	0	65	- 65	54.2
Motorcycling	3,765	0	+ 3,765	
Driving for fun	111,602	297	+ 11,305	
Four wheeling	1,579	13	+ 1,566	
Mountain Climbing	0	0	0	
Swimmming	411	15	+ 396	
Picnicking	122,013	13	+122,000	
Camping	101,609	289	+101,320	
Boating	562	0	+ 562	
Game Playing (playgrounds & fields)	806	26	+ 780	
Tennis	4	0	+ 4	
Golf	15	0	+ 15	
Fishing	3,427	551	+ 2,876	
Shooting/Hunting	417**	86	+ 331	
Skiing/ Snowshoeing	0	0	0	
Snowmobiling	473	0	+ 473	
Sledding-Tobogganning-Tubing	548	43	+ 505	
Ice Skating	11	32	- 21	17.5
Other	0	34	- 34	28.3
Total need (deficit)			- 120	100.0%

*Activity days: (def). participation by a person in an outdoor recreation activity for any period of a day.

**These supply figures were adjusted by BLM after consultation with Mr. Alan Everson, Senior Planner, Colorado Division of Parks. They were derived by totaling USFS acreages, national resource lands which have public access, Colorado Division of Wildlife acreage, U.S. Fish and Wildlife Service acreage, privately-owned hunting acreage plus lands leased by sportmens clubs.

SOURCE: NW Coal Final EIS, BLM, 1977.

APPENDIX G

SOCIOECONOMICS

APPENDIX G

TABLE 1

EMPLOYMENT CATEGORIES AND ESTABLISHMENTS,
RIO BLANCO COUNTY

SIC Code	Industry	Number of Employees	Number of Establishments
	Total	1,556	182
	Mining	966	48
10	Metal mining	(B)	2
108	Metal mining services	(B)	1
13	Oil & gas extraction	888	44
131	Crude petroleum & natural gas	612	23
138	Oil & gas field services	(E)	18
1389	Oil & gas field services, nec	(C)	16
	Contract Construction	71	17
17	Special trade contractors	53	12
	Manufacturing	40	9
	Transportation & Other Public Utilities	108	9
42	Trucking & warehousing	55	3
421	Trucking, local & long distance	55	3
	Wholesale Trade	24	8
	Retail Trade	226	44
58	Eating & drinking places	100	12
	Finance, Insurance & Real Estate	30	7
	Services	85	31
	Nonclassifiable Establishments	6	9

Note: A:0-19; B:20-99; C:100-249; E:250-499; F:500-999; G:1,000-2,499; H:2,500-4,999; I:5,000-9,999; J:10,000-24,999; K:25,000-49,999; L:50,000-99,999; M:100,000 plus.

Source: U.S. Bureau of Census. September 1977. County Business Patterns 1975. U.S. Government Printing Office. Washington, D.C.

APPENDIX G

TABLE 2

RIO BLANCO COUNTY, FAMILY INCOME
1975 - 1976 ESTIMATES

	1975	1976
Number of Families	1,367	1,378
Percent of Families		
Less than $5,000	13.0	12.1
$5,000-$7,999	20.5	19.6
$8,000-$9,999	10.9	6.1
$10,000-$14,999	30.0	33.6
$15,000 & Over	25.6	28.7
Median Family Income	$11,054	$11,534
Families Below Poverty Level[1]		
Number	130	130
Percent	10.1	10.1
Families with Female Head		
Number	71	71
Percent	5.5	5.5
Families with Female Head Below Poverty Level		
Number	9	9
Percent	0.7	0.7

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[1] Poverty definition is from the 1970 U.S Census. It is based on a definition originated by the Social Security Administration in 1964 and then modified by a Federal Interagency Commission. It provides a range of poverty income cutoffs adjusted by such factors as family size, sex of family head, number of children under 18 years of age, and farm and nonfarm residence and is based on a nutritionally adequate food plan designed by the Department of Agriculture. The poverty threshold published with the Census data for 1970 ranged from $1,487 for a female unrelated individual over 65 years of age living on a farm to $4,116 for a nonfarm family with male head and with 7 or more persons. The average poverty threshold for a nonfarm family of 4 headed by a male was $3,745.

Source: Colorado Department of Health, 1975-1976, 1978. Demographic Profile. Denver, Colorado.

APPENDIX G

TABLE 3

REVENUES AND EXPENDITURES, RIO BLANCO COUNTY
1980

	1980 Revenues
Taxes	1,780,722
General Property	937,423
Road & Bridge	412,054
Public Welfare	30,904
Public Hospital Fund	360,341
Specific Ownership	40,000
Sales	N/A
Licenses and Permit	80,550
Intergovernmental Revenue	1,465,582
Federal	239,094
State	1,219,921
Other Units	6,567
Charges for Current Services	150,000
Miscellaneous	158,270
Total Revenue	3,635,124

	1980 Expenditures
General Government	632,463
County Commissioners	282,133
Clerk and Recorder	117,166
Treasurer	72,637
Assessor	110,913
Plant Maintenance	49,614
Judicial	49,937
Public Safety	315,940
Law Enforcement	296,530
Fire	1,150
Other	18,260
Health and Hospitals	87,331
Auxiliary Services	534,759
Total Expenditures	1,620,430

APPENDIX G

SOCIOECONOMIC MULTIPLIERS

Type	Multiplier	Source
Population	2.0/new resident-employee or 2.0 x number of employees	CWACOG 1980, Regional Population Growth Monitoring Report, Nov. 1979
Secondary Service Employment	.7/new resident-employee or .7 x number of employees	CWACOG 1980, Regional Population Growth Monitoring Report, Nov. 1979
Total Induced Population	4.5/new resident employee or 4.5 x number of employees	CWACOG 1980, Regional Population Growth Monitoring Report, Nov. 1979
Required Number of Doctors for a Given Population	1.0/1000 population or 1.0 x Total Population/1000	VTN
Required Number of Dentists for a Given Population	.65/1000 population or .65 x Total Population/1000	VTN
Required Number of Nurses (RN) for a Given Population	3.5/1000 Population or 3.5 x Total Population/1000	VTN

APPENDIX G

SOCIOECONOMIC MULTIPLIERS

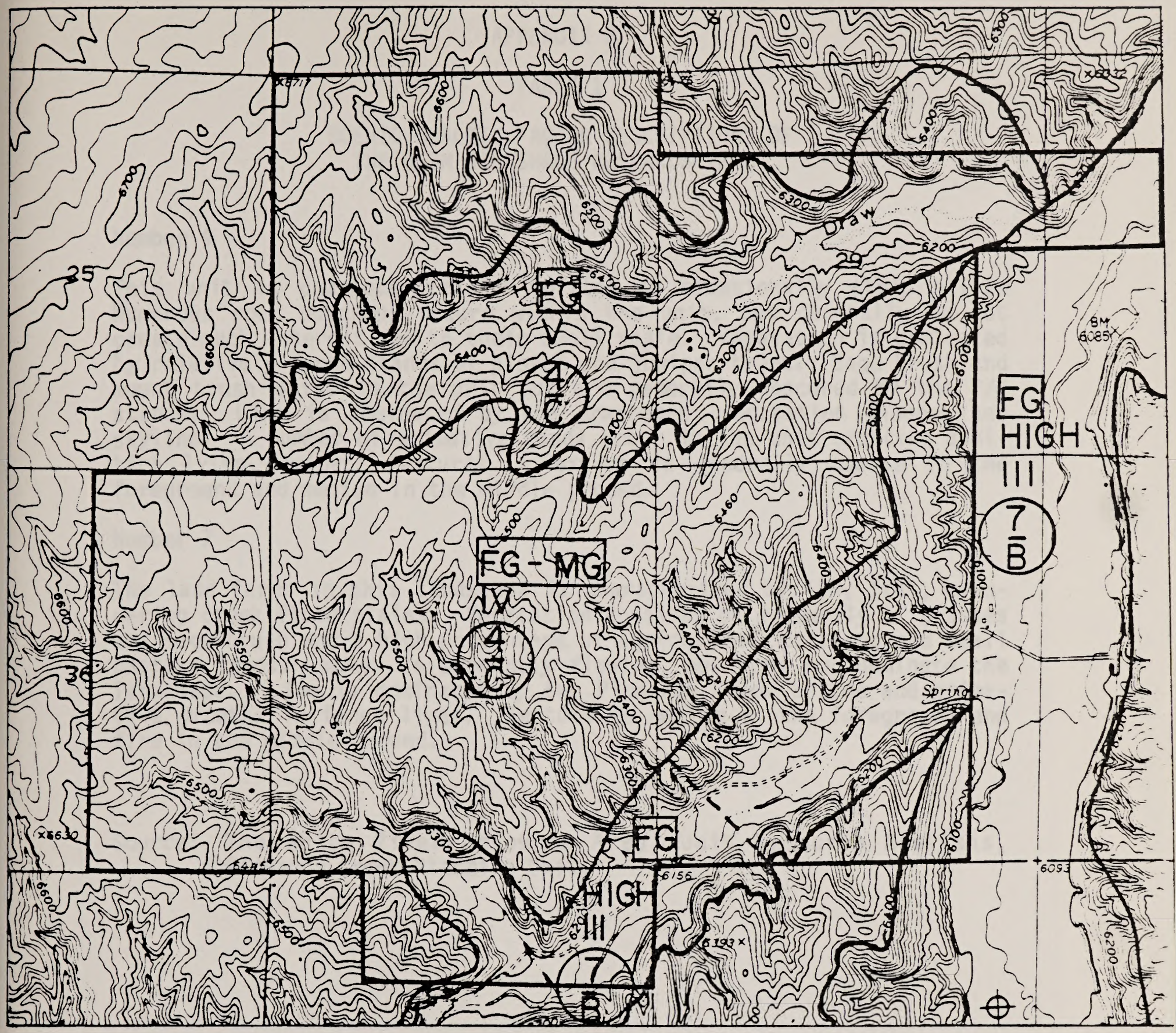
Type	Multiplier	Source
Population	2.0/new resident-employee or 2.0 x number of employees	ONACOG 1990, Regional Population Growth Monitoring Report, Nov. 1979
Secondary Service Employment	.7/new resident-employee or .7 x number of employees	ONACOG 1990, Regional Population Growth Monitoring Report, Nov. 1979
Total Labour Force	4.5/new resident employee or 4.5 x number of employees	ONACOG 1990, Regional Population Growth Monitoring Report, Nov. 1979
Required Number of Doctors for a Given Population	1.0/1000 population or 1.0 x Total Population/1000	VIA
Required Number of Dentists for a Given Population	.65/1000 population or .65 x Total Population/1000	VIA
Required Number of Nurses (RN) for a Given Population	3.5/1000 Population or 3.5 x Total Population/1000	VIA

Type	Multiplier	Source
Required Number of Nurses (LPN) for a	1.6/1000 Population or 1.6 x Total Population/1000	VTN
Required Number of Nurses Total for a Given Population	5.1/1000 Population or 5.1 x Total Population/1000	VTN
Elementary Students Induced by a Population Increase	15%/Population Increase or .15 x Population Increase	Bob King, Superintendent of Schools in Meeker, July 1978
Junior High Students Induced by a Population Increase	4.5%/Population Increase or .05 x Population Increase	Bob King, Superintendent of Schools in Meeker, July 1978
Senior High Students Induced by a Population Increase	6.0%/Population Increase or .06 x Population Increase	Bob King, Superintendent of Schools in Meeker, July 1978
Required Number of Police Personnel for a Given Population	2/1000 Population or 2 x Total Population/1000	VTN
Required Number of Police Vehicles for a Given Population	.5/1000 Population or .5 x Total Population/1000	VTN

Type	Multiplier	Source
Required Number of Fire Personnel for a Given Population	2/1000 Population or 2 x Total Population/1000	VTN
Required Number of Fire-trucks (Pumpers) for a Given Population	.5/1000 Population or .5 x Total Population/1000	VTN
Required Number of Fire-trucks (Ladder) for a Given Population	.5/1000 Population or .5 x Total Population/1000	VTN
Total Number of Required Firetrucks for a Given Population	1.0/1000 Population or .1 x Total Population/1000	VTN

APPENDIX H

AESTHETICS



SOURCE: White River Resource Area Unit
Resource Analysis

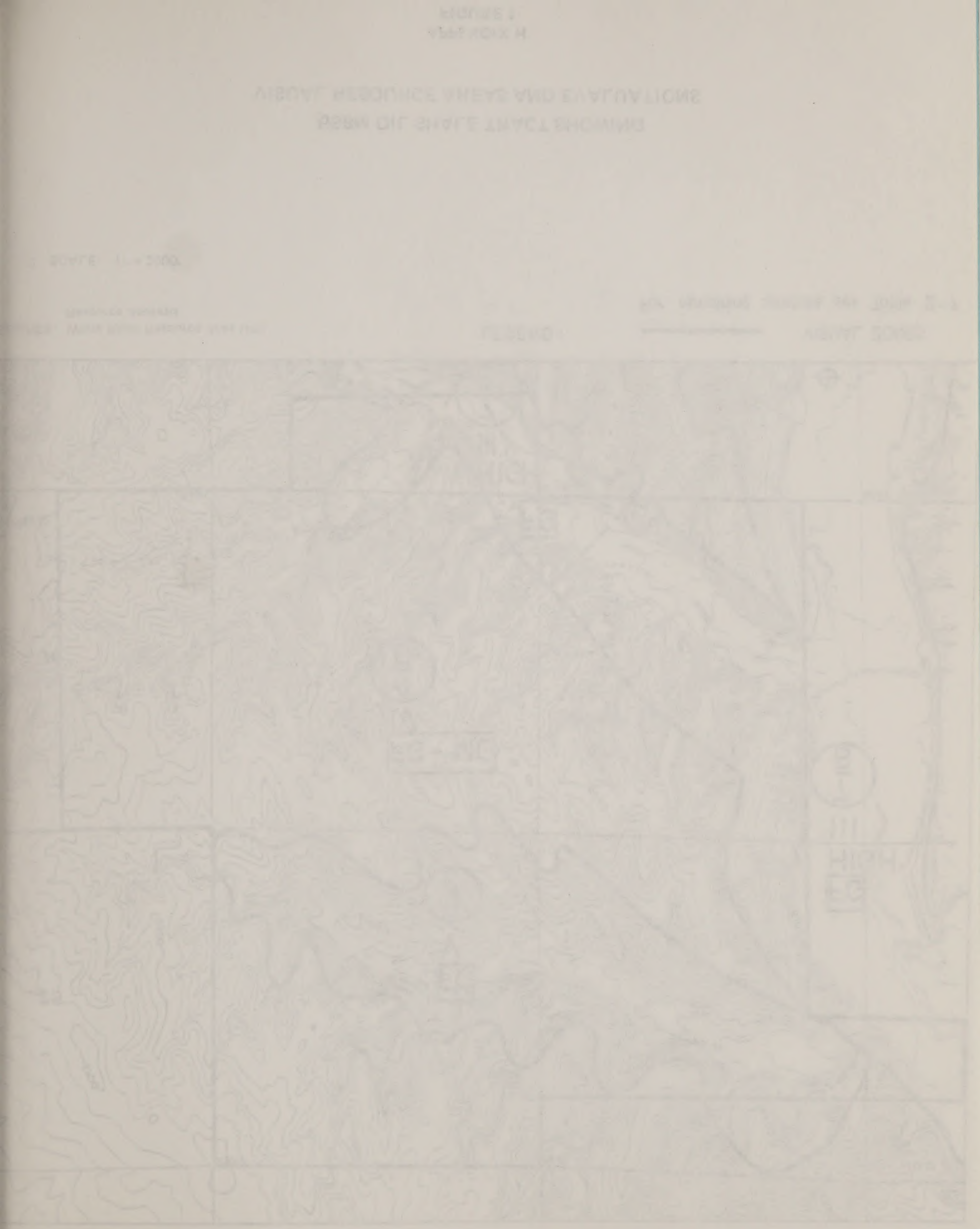
LEGEND : ——— VISUAL ZONES

For remaining symbols see Table 2-7

SCALE: 1" = 2000'

USBM OIL SHALE TRACT SHOWING
VISUAL RESOURCE AREAS AND EVALUATIONS

APPENDIX H
FIGURE 1



APPENDIX H

TABLE 1

SCENIC QUALITY FACTOR DESCRIPTIONS OF
THE USBM OIL SHALE RESEARCH TRACT

Number 4

This unit is characterized by rolling to occasionally steep hills. Numerous rock outcrops occurr within the unit, but generally do not create much interest due to their small scale. Vegatation is dominated by relatively dence stands of pinyon and juniper trees. Sage brush and mount brush exist in the unit but are generally obscured by the P/J stands. Line is dominated by the drainages, vegatation changes and skyline. A number of primative roads occur in the unit creating addition lying dominate features. Texture is generally coarse in the foreground and medium in the middle ground.

Number 7

The land forms in this landscape is characterized by low, flat, meandering creek flood plains. Vegatation consists of primarily of grasses and sage brush and a high percentage of agricultural patterns and small pasture lands. Water is presently flowing, but does not dominate the landscape. Line is dominated by the Piceance Creek bottom and primative growths in fence lines. Texture is medium in the foreground and fine in the middle ground.

Source: The White River Resource Area, Unit Resource Analysis, Piceance Creek Planning Unit.

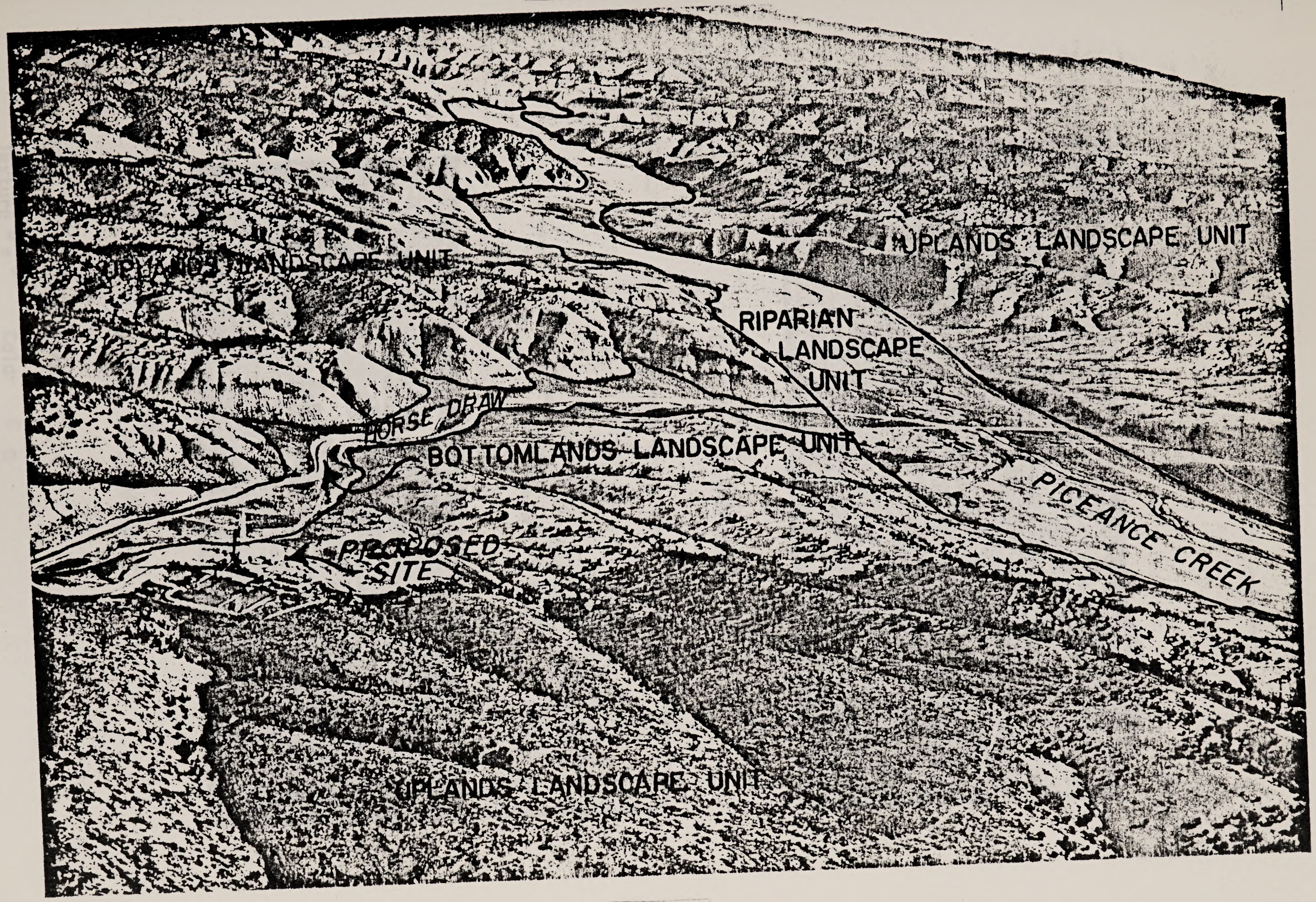


FIGURE 2

LANDSCAPE UNITS OF STUDY AREA





FIGURE 3
BOTTOMLANDS LANDSCAPE UNIT



FIGURE 4
UPLANDS LANDSCAPE UNIT

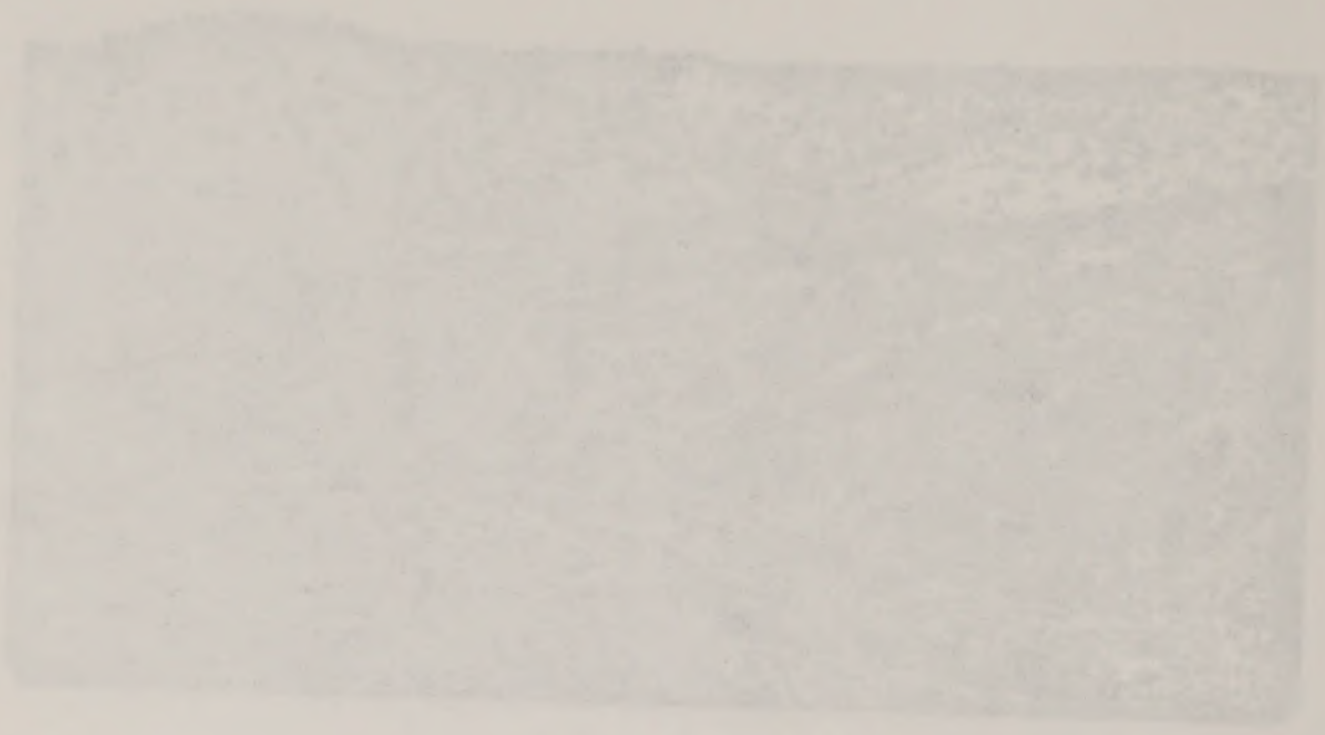
LEGEND

Line

Form

Texture

Color C C



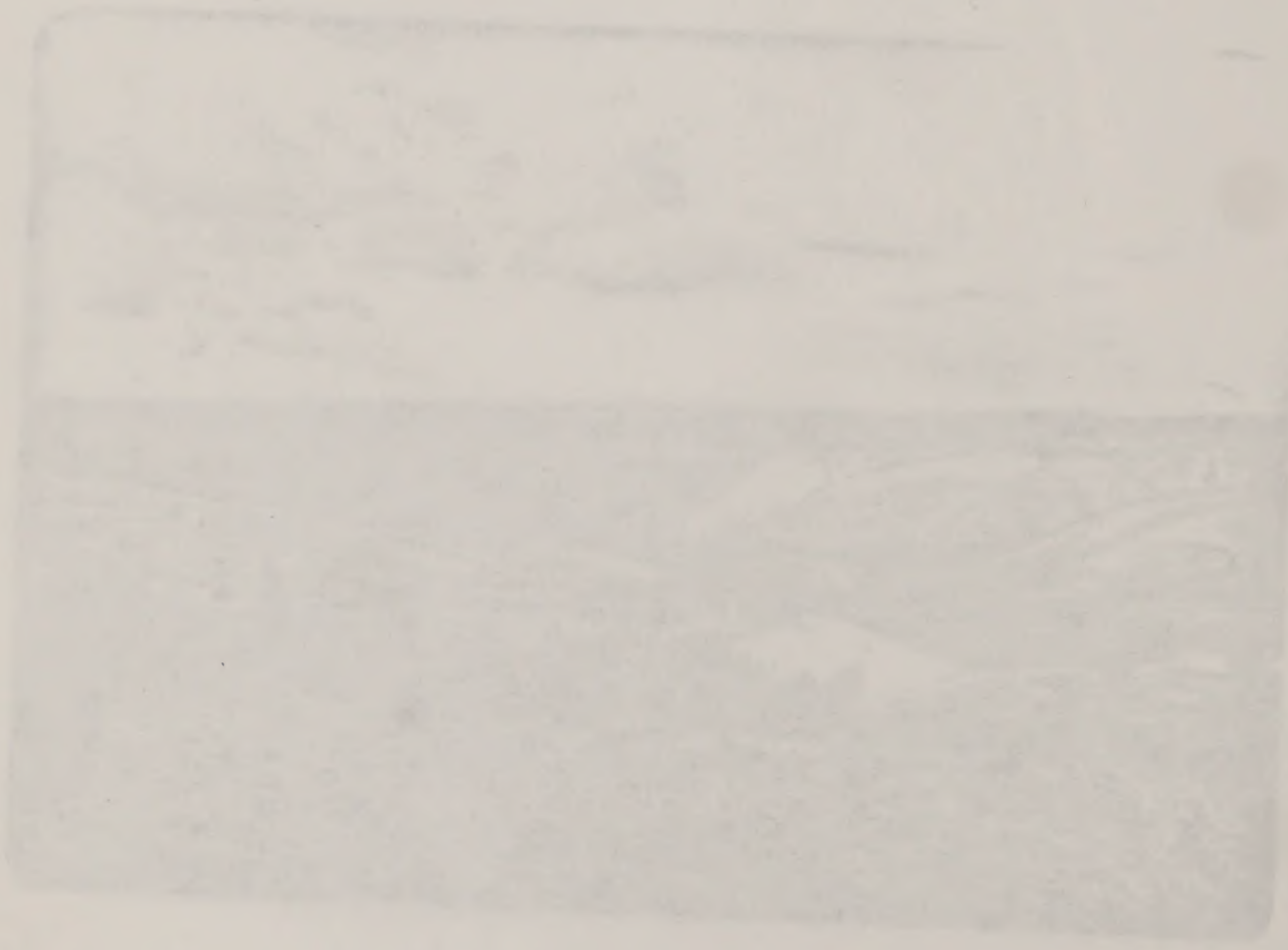




FIGURE 5

RIPARIAN LANDSCAPE UNIT

LEGEND

Line ~

Color C C



APPENDIX I

ARCHAEOLOGY AND PALEONTOLOGY

APPENDIX I

SUMMARY DESCRIPTION AND EVALUATION
OF PREHISTORIC CULTURAL RESOURCES

Site Number	Cultural Affiliation	Description (features and artifacts)	Level of Importance
5RB310	Unknown	Open Lithic (30mx50m): utilized flakes, 4 scrapers, 2 bifaces, lithic debitage	II
316	Unknown	Open Lithic (27mx56m): 2 projectile points, 1 utilized flake, 1 core, low lithic debitage amount	II
317	Archaic(?)	Open Lithic (100mx300m): 2 biface fragments, 1 projectile point	II
318	Unknown	Open Lithic (60mx100m):	III
319	Shoshoni	Open Camp (75mx550m): suspected teepee ring, 2 hearths, 1 rectangular pit w/ dirt walls; 4 Shoshoni ware sherds, 1 projectile point, 1 metal bead, biface fragments, lithic debitage	I
320	Late Prehistoric	Open Camp (40mx200m): 2 hearth areas; 1 projectile point, 2 biface fragments, 1 ground quartzite object, lithic debitage	II
321	Unknown	Open Lithic (37mx49m): 2 projectile point fragments, 2 utilized flakes, lithic debitage	II
5RB322	Unknown	Open Lithic (20mx20m): 1 utilized flake, 1 chopper, lithic debitage	II
323	Unknown	Open Camp (20m dia.): hearth w/burned bone & charcoal flakes; 1 pipe fragment, 1 biface, 1 core, utilized flakes, lithic debitage	I
324	Unknown	Open Lithic (50mx150m): 4 utilized flakes, 3 scrapers, lithic debitage	III
325	Unknown	Open Lithic (50mx150m): projectile point tips, 1 mano fragment, utilized flakes, scrapers, lithic debitage	II

APPENDIX I (Cont.)

SUMMARY DESCRIPTION AND EVALUATION
OF PREHISTORIC CULTURAL RESOURCES

Site Number	Cultural Affiliation	Description (features and artifacts)	Level of Importance
5RB326	Unknown	Open Lithic (45mx120m): 2 mano fragments, 1 scraper, 1 biface, 2 utilized flakes, lithic debitage	II
442	Unknown	Open Lithic (6mx80m): Scraper, core, projectile point fragment, lithic debitage	III
447	Archaic?	Open Lithic (3 sq. m): Projectile point, biface fragment, lithic debitage(s)	III
452	Unknown	Open Lithic (40mx20m): 3 lithic debitage concentrations	II

(1) Level of Importance Definitions

I Recommended as eligible for the NRHP; site contains important information of prehistoric cultures of the region

II Site contains scientific information supplemental to the understanding of prehistoric cultures of the region

III Site contains no further information beyond that recovered by the investigation

An Isolated Empire: A History of Northwest Colorado

Man's use and occupation of the northwestern corner of Colorado dates from about 10,000 years ago. The first men historically recorded were the Ute Indians. The Spanish were the first white men to see this region. The Spanish had been in the New World two centuries before their interest extended to northwestern Colorado. In 1776, the Dominquez-Escalante party set out to locate a feasible transportation and communication route between Spain's colonies in the southwest and California. Fears of the expanding interests of France and England forced the Spanish colonies to lay claim to vast areas of the west. Little economic potential was realized for the area. Even the gold found was not considered to be of a significant quality to justify establishing a settlement.

During the 1820's and 1830's, fur trading became the dominant economic activity in the region. Mountain men from Mexico and the United States set up trading posts in and around the region. Here the northern Utes, being friendlier, became involved with fur trading and learned of the White man's culture. Buffalo and beaver furs were transported to St. Louis. Fur trading lasted only until styles changed and sources were depleted.

Shortly before and following the collapse of the fur trade, several explorers came into this area. In 1844 John C. Fremont, who brought an army expedition into the Green River, Brown's Hole, and west on an official government mission designed to map the region and seek routes for new trails west. Fremont said very little about Colorado, but noted that, in his opinion, this country was nearly worhtless; in 1845 his second expedition into the area concluded much the same.

The next official exploration came in 1869, when John Wesley Powell was commissioned to map the Green and Colorado Rivers. He gathered much new data about the Great Basin, noting that the Brown's Park area was of little value, and the only way this part of the state would ever develop would be with irrigation.

With the westward expansion of the nation in the 1850's, the cattle industry began in the area. The practice of open grazing slowly depleted the traditional hunting grounds of the Indians, forcing them to steal livestock to maintain an existence. This helped to set the stage for the Meeker Massacre and the Thornburg Battle. The Ute Nation owned all of northwestern Colorado by the terms of the Brunot Treaty of 1873. By this treaty two reservations were established: the Los Pinos Agency for the Southern Utes, and the White River Agency for the Northern Utes. A series of agents had come and gone by 1879, and the next to the last, Reverend H.A. Danforth, resigned in disgust over U.S. Indian policy and its failure to keep promises to his wards. He was replaced by Nathan C. Meeker in 1879. Meeker felt that the American native was not productive, and that to make the Indian a useful citizen, he had to be taught the ways of the white men.

The Utes were not willing to give up their traditional ways for Meeker or any other white man. The conflict between the two cultures developed over agriculture and Meeker's compulsory conversion of the Ute from a nomadic to a sedentary citizen. Finally, in September of 1879, the explosion came. Meeker was shoved by a Ute chief, Johnson, and he wired for help from Fort Steele, Wyoming. By the end of that month, troops were sent under the command of Major Thomas T. Thornburgh. The Thornburgh detachment was ambushed along Milk Creek in Moffat County, despite attempts by both Thornburgh and the Ute Chiefs, Douglas and Colorow, to avoid hostilities. The Thornburgh Battle occurred at the same time the White River Agency was attacked by Utes under Chief Johnson. Meeker and eleven male employees were killed; Meeker's wife, daughter, and several other women were captured. After nearly three months of negotiations, with the help of powerful Chief Ouray and his wife, Chipeta, the women were released; the leaders of the rebellion gave themselves up, and a commission was established to determine guilt. These two events led to the removal of the Indians to a reservation in eastern Utah.

Once the northwest corner was cleared of Indians, homesteaders moved in, and the open range cattle industry expanded. Between 1880 and 1895 a series of towns sprang up and became merchandising centers. Steamboat Springs was founded in 1885, Craig in 1889, Hayden in 1895, Meeker in 1882, Rangely in 1882, and numerous smaller places like Lay, Maybell, and Axial developed as a direct consequence of the Ute removal.

The introduction of cattle to the range provided a major industry in the northwest corner for nearly fifty years. However, there were conflicts over use of the land. Homesteaders tried to settle land that was used by cattlemen. In some cases they were driven off, while in others they persisted. Cattlemen also fought with sheep raisers, who by the 1890's were beginning to bring sheep into the lush pastures of the forest lands in the Elk River Valley and other valleys. Violent conflicts erupted between these two factions, despite the fact that most cattlemen did not own the land they used, which was nearly all public domain. Sheepmen were murdered and sheep were destroyed. The climax of the sheep wars came in Rio Blanco county with the "battle" of Yellowjacket Pass. That year the Colorado State Militia was called in and peace was restored.

In 1934 the Taylor Grazing Service was created to control grazing (and over-grazing) on public lands other than forest withdrawals. This service allotted land to cattlemen, sheepmen, and others for grazing purposes. For all practical purposes, the balance of public domain land in northwestern Colordo was withdrawn from homesteading by this Act, and the era of the open range ended. In 1946 the General Land Office, the original dispenser of public lands, and the Grazing Service were merged and became the Bureau of Land Management. This organization has continued to issue grazing permits, and for the most part has kept the public domain from being overused.

The cattle industry was not the only factor in the development of northwestern Colorado. New transportation routes developed to serve the various communities that were growing in the region as the settlers

came into the river valleys of the Elk, the Little Snake, the Yampa, the Green and the White. Mineral exploitation took place in areas like Fortification Creek and Blue Mountain, while hay and grains were grown to provide food and fodder. The Yampa Valley became a major hay raising area, while the far west was still a cattle region.

In Middle Park, one of the earliest areas of settlement, development continued. Tourism, a mainstay since the 1860's, continued to grow there, and settlers took up increasing areas along the creeks where they raised cattle and some hay. To the north - in the North Park area - settlement was later; ranchers did not turn this land into cattle range until the 1880's. It was discovered that hay was a good local crop, and the area became the source of some of the world's finest hay. Mining continued on Independence Mountain; around the turn of the century coal and copper was discovered in North Park. A small boom ensued, but nothing substantial came of it.

When the famous Moffat Road (Denver and Northwest Pacific) came into Middle Park, then pushed on to Steamboat Springs, and later into Craig, transportation became cheaper and easier. For the first time cattle could be shipped directly to Denver without long drives; sheep also could be shipped more directly; hay, coal, wheat and other crops could be exported easily and at a profit, while the land was opened to more settlers.

The hope was that the Yampa Coal Fields would provide the basic revenue for the Moffat Road; however, while a coal "boom" occurred in towns like Oak Creek, Phippsburg, Mount Harris, and others, the road was bankrupt by 1909 and reorganized as the Denver and Salt Lake.

Another boom during this period was oil. From its discovery in the White River region in the 1890's, to the exploitation of the minerals near Rangely in 1902 (Poole Well), oil was a marginal product. By 1920 the industry had developed to the point that numerous oil fields, such as the Moffat, Iles, Rangely, Danforth and other areas, were in full production.

A final boom occurred with the construction of the Moffat Tunnel, begun in 1923 and completed in 1927. With the completion of the tunnel, it was assumed that the Moffat Road would be finished to Salt Lake City, and the northwest would be revived. The Moffat Tunnel shortened the route of the railroad; however, because of the poor financial condition of the Moffat Road, the Denver and Rio Grande Western leased the right-of-way. By the 1930's the Dotsero Cutoff was completed and, for all practical purposes, the Craig route became a branch line. The northwest again languished.

Since the 1930's the northwestern corner of Colorado has subsisted on agriculture, oil, some coal, and more recently tourists, mainly skiers. Within the last ten years oil shale development has shown more promise; more importantly, due to the national energy demands of the last few years, the coal industry has been revived and a new boom seems imminent.

This region's history was one of constant "booms" that never worked out. From fur to mining, cattle to oil, coal to oil shale and back to coal, the northwest corner of Colorado showed great promise, but for various reasons, it has never been able to fulfill the dream that seemed so real.

ARCHAEOLOGICAL RECONNAISSANCE OF THE BUREAU OF MINES PILOT OIL SHALE MINE

Calvin H. Jennings
Principal Investigator

and

Michael G. Spitzer
Field Supervisor

Cultural Resource Management Report 4
October 1976

Laboratory of Public Archaeology
Colorado State University
Fort Collins, Colorado 80523

Prepared for the Bureau of Mines
Contract No. J0265026

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ABSTRACT

Under contract with the Bureau of Mines, the Laboratory of Public Archaeology, Colorado State University, undertook an archaeological reconnaissance of a selected area of land in the Piceance Basin, Northwestern Colorado, subject to future disturbance by a pilot oil shale mine. Approximately four sections were intensively surveyed with the resulting discovery of 12 prehistoric sites and 23 isolated finds. A detailed description of the fieldwork, results, and recommendations for future action are presented in this report.

PROJECT DEVELOPMENT AND DESIGN

This archaeological reconnaissance was performed under contract with the Bureau of Mines, ~~10575 W. 13th St.~~ BUILD 20. DENVER FEDERAL CENTER, ~~Lakewood~~, Colorado. The proposed development is a pilot oil shale mine designed to explore oil shale production.

The development area consists of approximately four sections in Rio Blanco County, Colorado (Figs. 1, 2). This area lies west of Piceance Creek and includes portions of Horse Draw and Ryan Gulch. The legal description is as follows:

SW¼NW¼,	Sec. 28,	T1s, R97w
S½	Sec. 29,	T1s, R97w
W½ SE¼,	Sec. 29,	T1s, R97w
SW¼,	Sec. 29,	T1s, R97w
All of	Sec. 30,	T1s, R97w
All of	Sec. 31,	T1s, R97w
W3/4,	Sec. 32,	T1s, R97w
E½,	Sec. 36,	T1s, R98w
NE¼NW¼,	Sec. 6,	T2s, R97w
N½ NE¼,	Sec. 6,	T2s, R97w

The archaeological reconnaissance was conducted on June 9, 1976 through June 13, 1976 by Michael G. Spitzer, Field Supervisor, and four crew members, including David M. Hall, Kevin T. Jones, Linda L. Spitzer, and Gayle I. King. All members of the crew are employed by the Laboratory of Public Archaeology under the direction of Calvin H. Jennings.

LITERATURE SEARCH

A preliminary literature search was conducted prior to entering the field. However, the work done in this area has been limited to prior work done through the Laboratory of Public Archaeology.

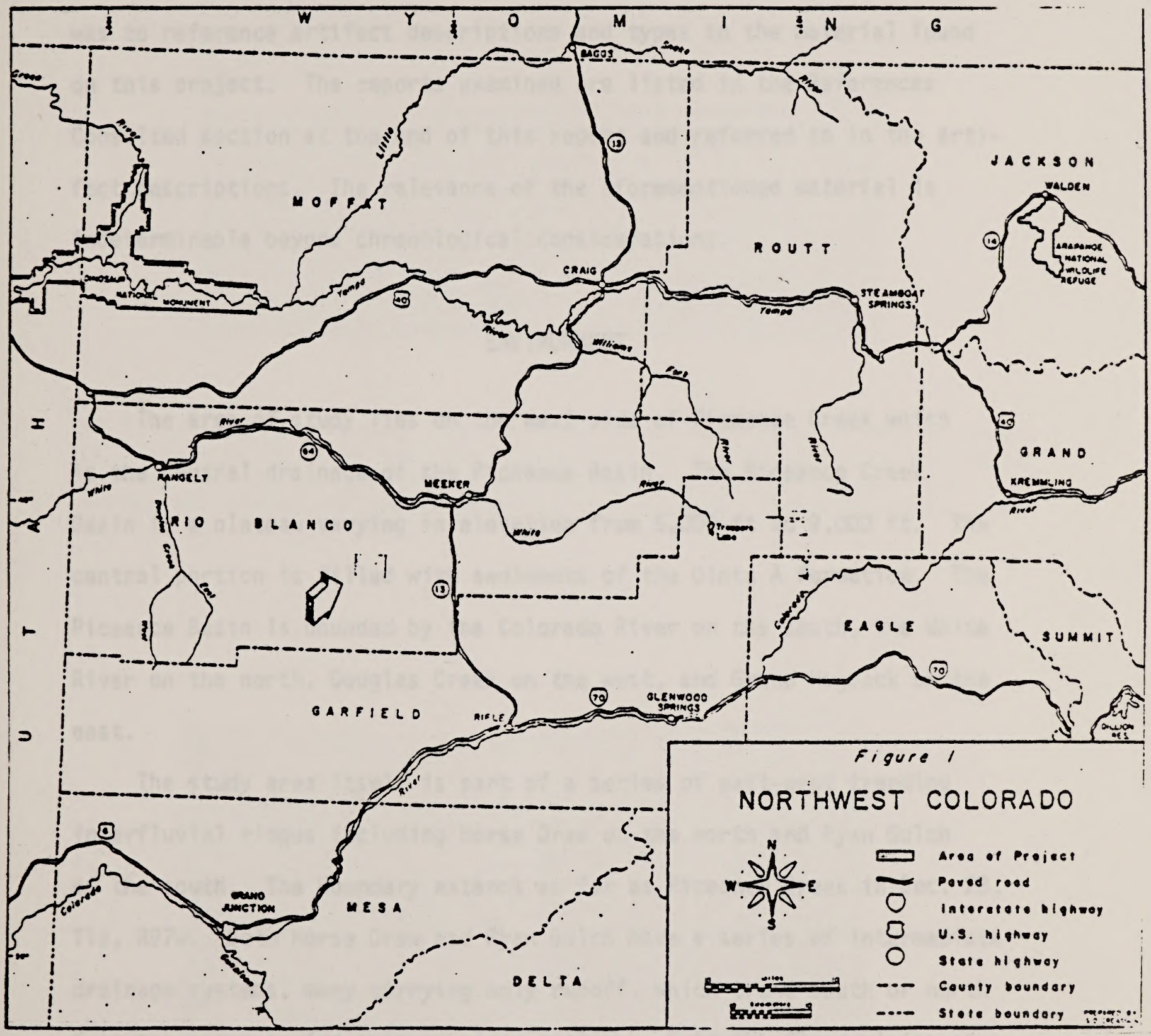
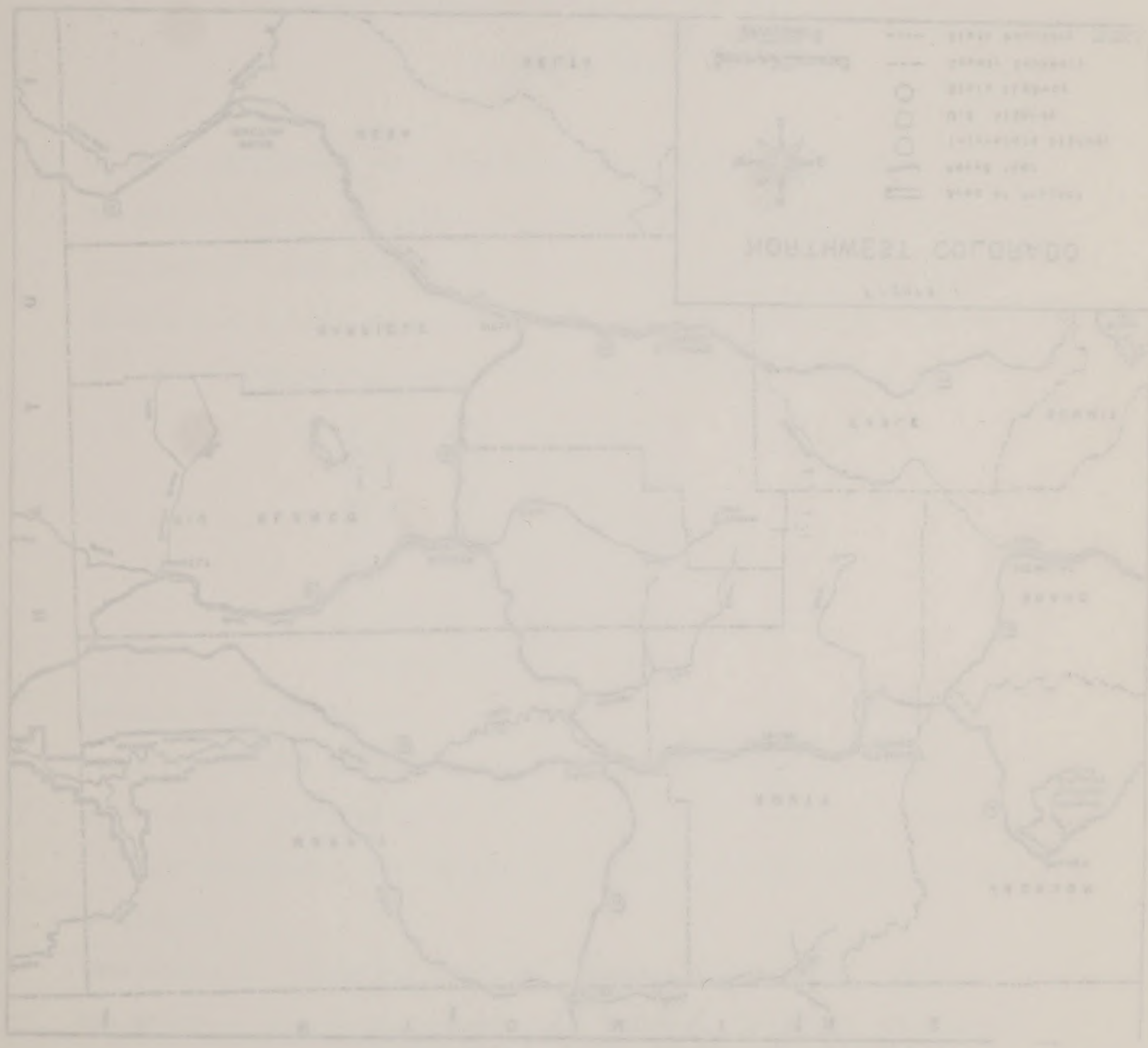


Figure 1

NORTHWEST COLORADO



Further archival research was conducted after returning from the field. Neighboring areas, particularly Dinosaur National Monument and eastern Utah, were investigated. The primary reason for this procedure was to reference artifact descriptions and types to the material found on this project. The reports examined are listed in the References Consulted section at the end of this report and referred to in the artifact descriptions. The relevance of the aforementioned material is indeterminable beyond chronological considerations.

ENVIRONMENT

The area of study lies on the west side of Piceance Creek which is the central drainage of the Piceance Basin. The Piceance Creek Basin is a plateau varying in elevation from 5,000 ft to 9,000 ft. The central portion is filled with sediments of the Uinta A formation. The Piceance Basin is bounded by the Colorado River on the south, the White River on the north, Douglas Creek on the west, and Grand Hogback on the east.

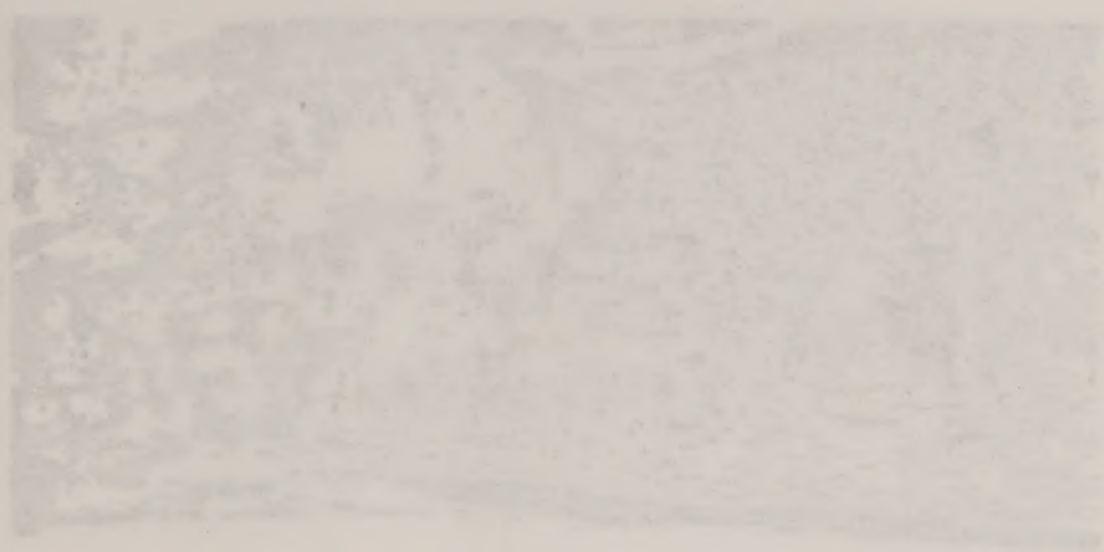
The study area itself is part of a series of east-west trending interfluvial ridges including Horse Draw on the north and Ryan Gulch on the south. The boundary extends as far as Piceance Creek in Sec. 28, T1s, R97w. Both Horse Draw and Ryan Gulch have a series of intermediate drainage systems, many carrying only runoff, which trend south or north from the accompanying primary ridge systems. From the flood plains at the lowest elevation of 6,080 ft to the highest point in the study area at 6,700 ft there is some diversity in aspect, soils, vegetation, and water availability (Figs. 3, 4, 5, 6).

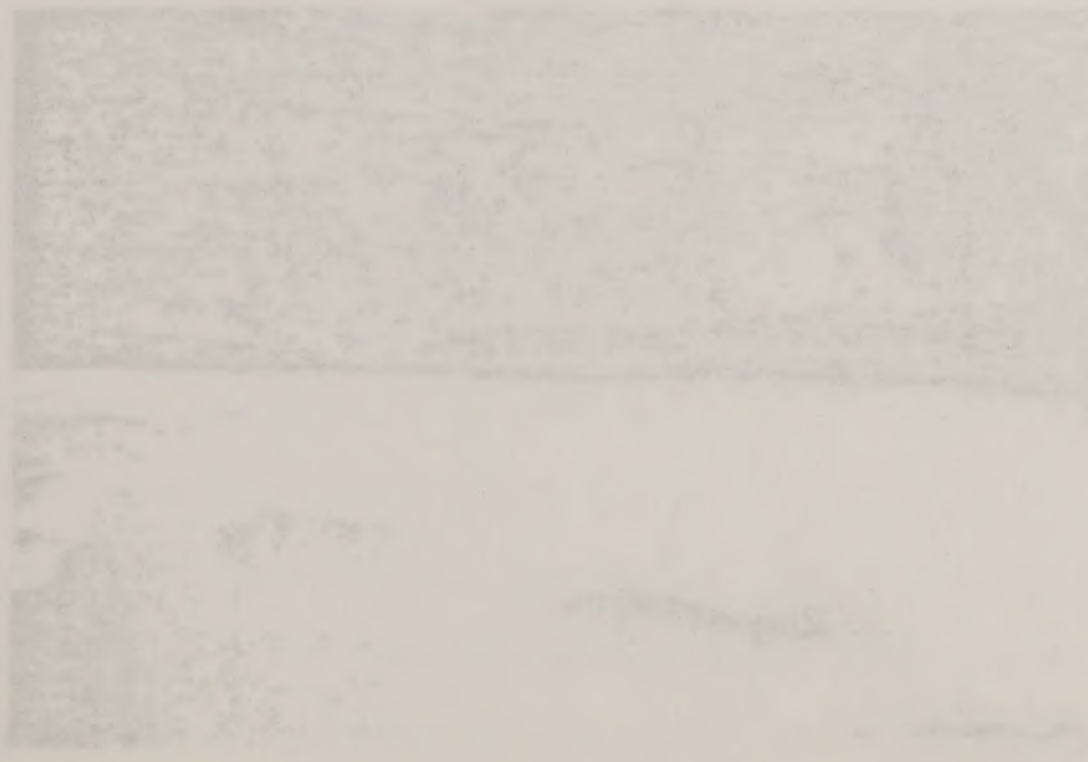


FIGURE 3. Top of a Primary Interfluvial Ridge, view faces northwest toward the confluence of Horse Draw and Piceance Creek. Note that this particular area has been chained and no longer supports tall juniper trees. The predominant vegetation is now sagebrush and grasses. Taken from NE¼, SW¼, NW¼, Section 31, T1s, R97w.



FIGURE 4. Unnamed Seasonal Drainage, view faces east. This is a typical quarternary drainage of Piceance Creek and supports juniper and pinon upslope with dense sage on the bottoms. Taken from NE¼, SE¼, NE¼, Section 36, T1s, R98w.





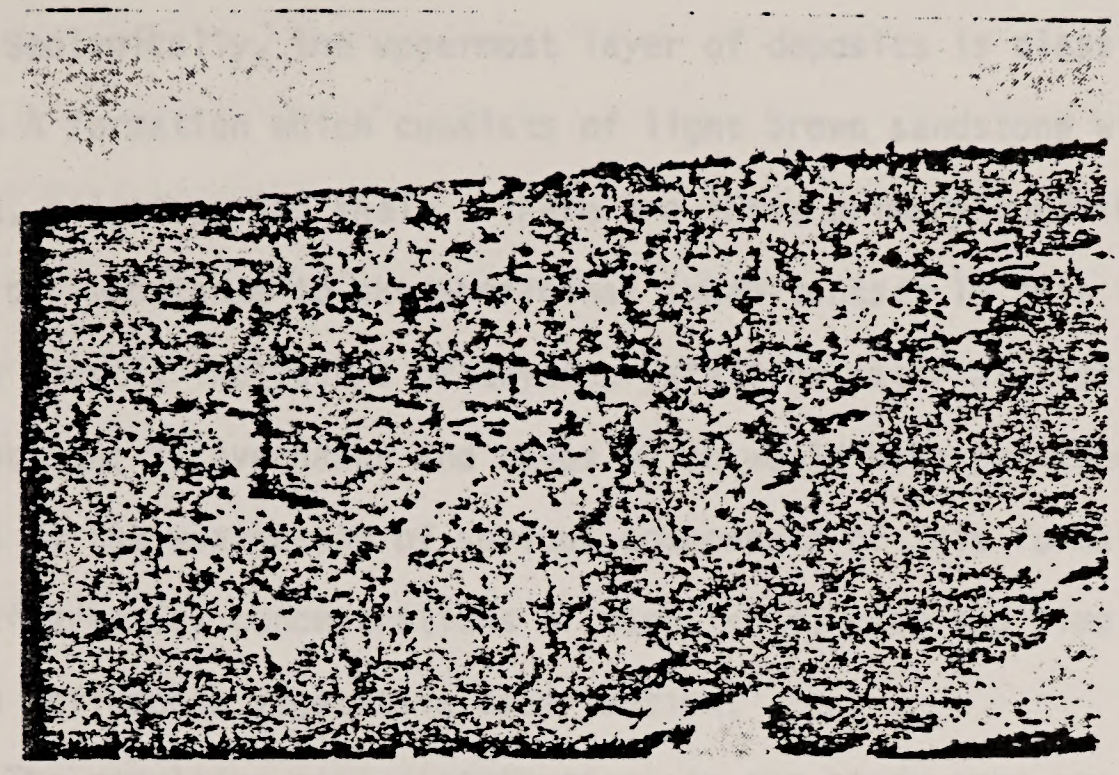


FIGURE 5. Unnamed Seasonal Drainage, view faces west. This is a large tertiary drainage of Piceance Creek. It flows into Ryan Gulch. Note the dense sage growth on the bottoms and the juniper upslope and on the ridge-tops. There is an access road and drill pad in the lower center of picture. Taken fromNW¼, NW¼, NE¼, Section 6, T1s, R98w.

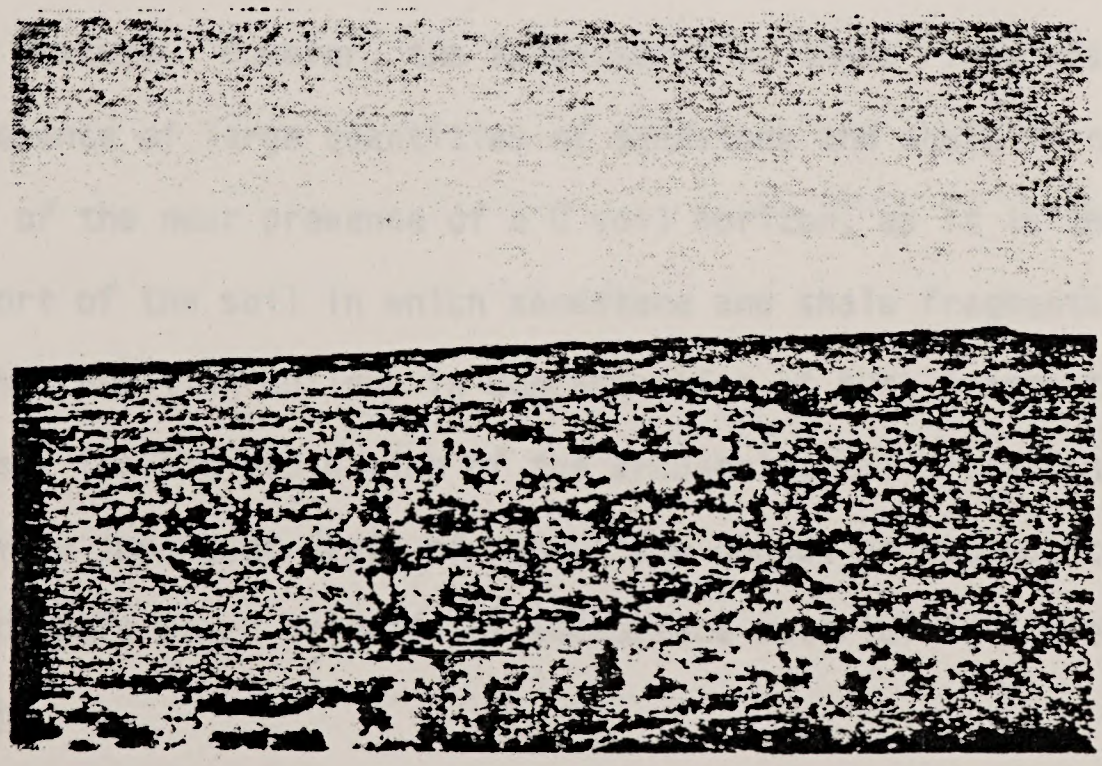
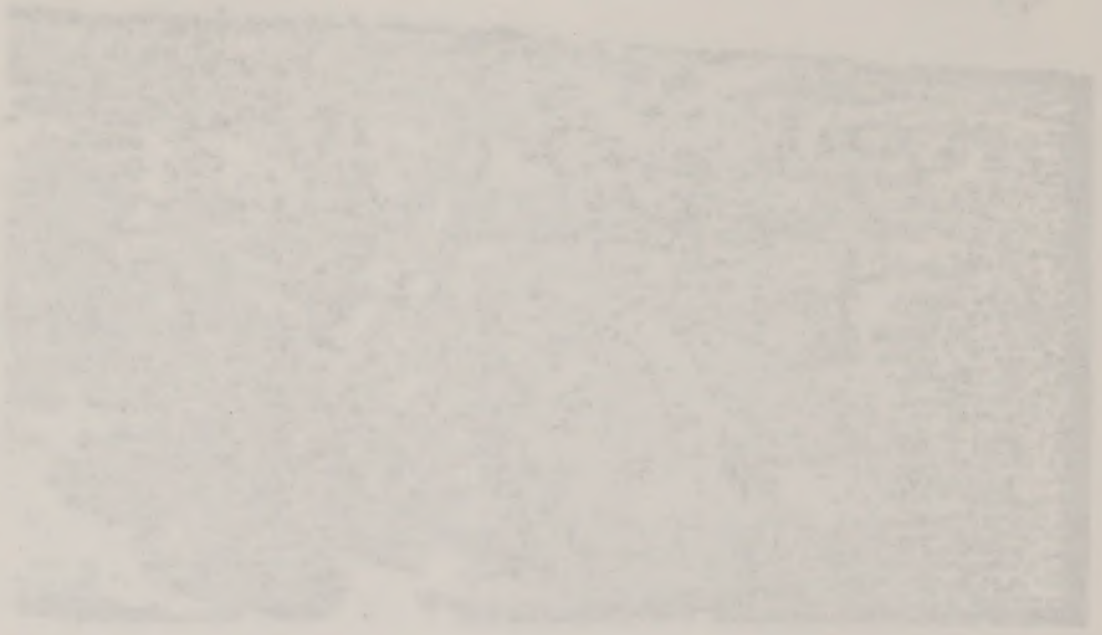
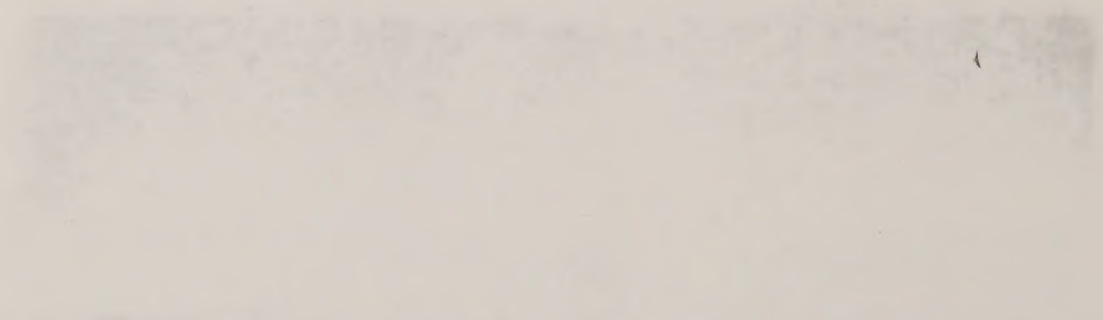


FIGURE 6. Chained Area on Top of Interfluvial Ridge, view faces east. Note the extensive disturbance. The edge of the disturbed area is outlined by juniper in the background. Taken from NE¼, SW¼, NE¼, Section 36, T1s, R98w.







Geology and Soils

Geologically, the uppermost layer of deposits is classified as the Uinta A formation which consists of light brown sandstone with marlstone, siltstone and shale. There are three primary contributing factors of importance to the aboriginal inhabitants: 1) this formation lacks clastic inclusions of cryptocrystalline materials for tool production; 2) overhangs and caves which would have provided shelter are rare; 3) the weathering of various components of this formation result in differential concentrations of sand, silt, clay and lime in the soil which influences vegetative distribution.

The resulting soil distributions in the study area are of two general classes (Fox 1973). The Piceance Creek and Ryan Gulch flood plains are cool, deep to moderately deep, well drained to poorly drained, moderately coarse to moderately fine-grained soils. The ridgetops have generally shallow to moderately shallow soils with coarse-grained to cobbly texture. However, the appearances on these ridgetops are deceiving. The presence of large quantities of sandstone and shale is not so indicative of the near presence of a C soil horizon, as it is the aeolian transport of the soil in which sandstone and shale fragments are present with the resulting buildup in concentration of such fragments. This is important for the evaluation of the archaeological situation because a relatively important depth of deposition cannot be automatically discounted where other evidence of subsurface material is present.

Climate

The study area's climate is classifiable as a mid-latitude steppe with summer-winter extremes and a short growing season. The Piceance Basin, as a whole, is protected from traveling weather disturbances by

major topographic features which create infrequent, rapid changes in daily air temperatures and weather conditions. Precipitation is strongly influenced by elevation and is highly variable from year to year, but, in general, the average for the area ranges from between 12 and 15 in. Generally, the windflow pattern is from the west and then to the north following Piceance Creek.

Hydrology

The primary water source is Piceance Creek. Piceance Creek is a permanent stream and would have provided a satisfactory water supply to semi-sedentary or nomadic people.

The local tributaries of Piceance Creek are either seasonal drainages or strictly runoff. The peak flows for runoff occur during the snowmelt in March, April, and May.

Springs appear and disappear in a matter of years around the area and it would be extremely difficult to determine when they existed. One small seep was located in the course of the survey, but no sites were located in the vicinity of the seep. It consisted of slow seepage which was reached after digging approximately 2 x 2 ft into the sand.

Vegetation

Roughly outlined, there are three vegetation zones in the study area. On the flood plains of Ryan Gulch, Horse Draw, and Piceance Creek the predominant species is sagebrush (*Artemisia*, sp.) which grows to heights in excess of six ft. On some of the south-facing slopes and on central portions of some of the ridgetops sage (*Artemisia*, sp.) also predominates but is much shorter, usually less than 2½ ft. The remainder of the ridgetops have varying densities of pinon-juniper forest.

In addition to the latter, a variety of other species grow here. Service-berry (*Amelanchier*, sp.) and mountain mahogany (*Cercocarpus*, sp.) are found on north-facing slopes. Prickly pear (*Opuntia*, sp.) is widely distributed throughout, as are local grasses. The remaining inventory includes saltbrush (*Atriplex L.*), cheatgrass (*Bromus techtorum*, sp.), rabbit brush (*Chrysothamnus*, sp.), Indian paint brush (*Castilleja*, sp.), Columbine (*Aquileguia*, sp.), Indian ricegrass (*Oruzopsis*, sp.), crested wheat (*Agropyron*, sp.) and wild onion (*Alluim*, sp.).

Fauna

There are a large variety of animal species in this area, including birds, reptiles, mammals, a few fish, and amphibians.

A number of birds reside in the area. Raptors of several kinds are present, but are not of importance as food resources. Summering waterfowl found in Piceance Creek include both ducks and geese. A few of these winter here, also. In addition, sage grouse are found in nearby areas.

Predatory mammals once found in the area include mountain lions, bobcats, bear, and coyotes. Coyotes are the only predators remaining in the area. Mountain lions have been reported on the nearby Roan Plateau and Cathedral Bluffs.

Rodents abound in the area, but cottontail constitute the only significant potential food resource among the small mammals.

Among the large game animals there are Mule deer and elk. The Mule deer winter in the Piceance Creek Basin and are plentiful, judging from the hunter kills and game reports. Elk do not inhabit the immediate vicinity but are found to the south in the summer at higher elevations and move to surrounding areas in the lower elevations in the winter.

Paleoclimatic Conditions

Due to the lack of suitable studies of paleoclimatic conditions through the study of Pleistocene soils, pollen analysis, etc., little can be said concerning previous conditions.

Presumably, in the not-too-distant past, the conditions were generally similar to those of the present. Pinon and game would have provided suitable resources for exploitative purposes of the aboriginal inhabitants. The water availability is unpredictable, except to state that local springs may have existed in addition to the major tributaries and seasonal runoff.

TECHNIQUES

Due to the potential nature of the disturbance, the area under consideration was intensively surveyed. A few areas were not intensively surveyed, but all were at least viewed from a distance. The portions rejected for the purpose of foot survey were those that had greater than a 15% grade, rendering them undesirable for habitation. Of course, potential rock shelters were investigated thoroughly.

When a site was located, the crew thoroughly investigated the surface and temporarily marked artifact locations. Then all artifacts were mapped in using a tripod-mounted Brunton Pocket Transit and a 50 m tape. At the conclusion of this procedure, four transects were run from the datum along the long and short axes of the site. A 2 m wide belt on either side of the transect centerline was completely collected, including debitage. In addition, the sites were recorded on Archaeological Survey of Colorado Inventory Sheets, providing information on the location, character of the site, vegetation, depth, and character of the deposits

and artifactual finds. Any features on the site were recorded on special forms designed for that purpose. Photographs were taken of each feature, and of the site.

Artifacts collected were transported to the Laboratory of Public Archaeology at the conclusion of the fieldwork, where they were cataloged, analyzed for temporal considerations, and stored. Further information on diagnostic artifacts is available in the following section.

CULTURAL RESOURCES

This reconnaissance yielded 12 sites and 23 isolated finds for the study area. A wide variety of artifactual material was discovered on sites ranging in size from 20 m in diameter to an excess of 1/3 mi long. In addition to debitage, the range of artifactual materials includes projectile points, bifaces, scrapers, utilized flakes, choppers, drills, manos, metate, a bead, and a pipe fragment. Features found included a Teepee ring, hearths, and an unidentified rectangular pit.

SITE 5RB316 (Fig. 8)

LOCATION

TYPE: Open Lithic

DESCRIPTION The site, at an elevation of 6530 feet, is on a fingerlike ridge bounded on the west and south by an unnamed seasonal drainage and on the east by an arroyo which confludes with the seasonal drainage. The site is approximately 500 meters northwest of the confluence of the unnamed seasonal drainage and Horse Draw. The onsite and surrounding vegetation is relatively dense pinon-juniper with sage (*Artemisia*, sp.), prickly pear (*Opuntia*, sp.), and sparse local grasses. The site location allows an excellent visual command of the aforementioned drainages and the ridges to the east, south and west. The view to the north is restricted due to the pinon-juniper on these ridges. The site area, 27 meters by 56 meters, has a low lithic density while the tool density was relatively high, yielding two projectile points, one utilized flake and a core.

DIAGNOSTIC ARTIFACTS

Projectile Point

5RB316.3 - Long blade, short stem, lenticular cross section, one staright and one convex side, corner notches, slightly concave base. (Fig. 23b)

5RB316.4 - Medium triangular blade, plano-convex cross section, short stem, corner notched, straight base. (Fig. 23c)

EVALUATION This site does not meet the criteria for nomination to the NRHP. The indications of buried material make it of potential scientific value and therefore, prior to any disturbance of the site, it should be salvaged as a part of a competent archaeological research program.



FIGURE 7. 5RB310, general view from the south. This view is from above the site further up the ridge. Michael Spitzer is in the center of the photograph.



FIGURE 8. 5RB316, general view from the south. The site is in the foreground.





SITE 5RB317 (Fig. 9)

LOCATION

TYPE: Open Lithic

DESCRIPTION The site, elevation 6540 feet, is on a flat ridgetop overlooking Horse Draw 100 meters to the south. The ridge is one of a series of south trending ridges which is divided by seasonal drainages trending south into Horse Draw.
The vegetation is a mixed distribution of pinon-juniper, Opuntia, serviceberry (*Amelanchier*, sp.), mountain mahogany (*Cercocarpus*, sp.), rabbitbrush (*Chrysothamnus*, sp.), short sage (*Artemisia*, sp.), Indian rice grass (*Oryzopsis*, sp.), columbine (*Aquileguia*, sp.) and local grasses. The view is restricted to the north up the ridge, however, the view is excellent to the adjacent ridges on the east, west and south toward Horse Draw.
The site, 100 meters by 300 meters, had its primary lithic concentration in a 50 meter diameter area. The inventory includes two biface fragments, one projectile point and four paleontological specimens.

DIAGNOSTIC ARTIFACTS Projectile Point

5RB317.5 - This is a stemmed, elongate, triangular form with straight edges and a short, broad, expanding base. This type shows broad corner notches and has a small basal notch. The spur and tang are blunted. (Fig. 23d)

EVALUATION This site lacks the attributes necessary for nomination to the NRHP. However this site is of potential scientific value for the study of local prehistory due to our lack of knowledge of transformation processes caused by chaining. Consequently, testing should be done to further determine the value of this site prior to any disturbance.
Furthermore, the presence of paleontological specimens indicates a need for evaluation by a qualified paleontologist.

SITE 5RB318 (Fig. 10)

LOCATION

TYPE: Open Lithic

DESCRIPTION The site, elevation 6535 feet, is located just off the northwest side of a small knoll on a large, flat ridgetop. Immediately east of the site, approximately 250 meters, is the head of an unnamed seasonal drainage which runs 950 meters northeast into Horse Draw. Approximately 250 meters to the southwest is the head of another drainage which flows 1600 meters southeast into Ryan Gulch. To the northwest and southeast of the site is a large, flat ridgetop.
Onsite vegetation includes short sagebrush (*Artemisia*, sp.), rabbitbrush (*Chrysothamnus*, sp.), Indian rice grass (*Oruzopsis*, sp.), crested wheat (*Agropyron*, sp.), and local grasses. The site is on the edge of a juniper grove on the east. The site affords an excellent view of the primary ridge to the north and west and of the adjacent areas to the east. The view is restricted to the south due to the knoll.

DIAGNOSTIC ARTIFACTS

None

EVALUATION 5RB318 lacks any scientific value or potential for yielding information important to prehistory. The site should not be nominated to the NRHP. No further action is required with regard to this site.

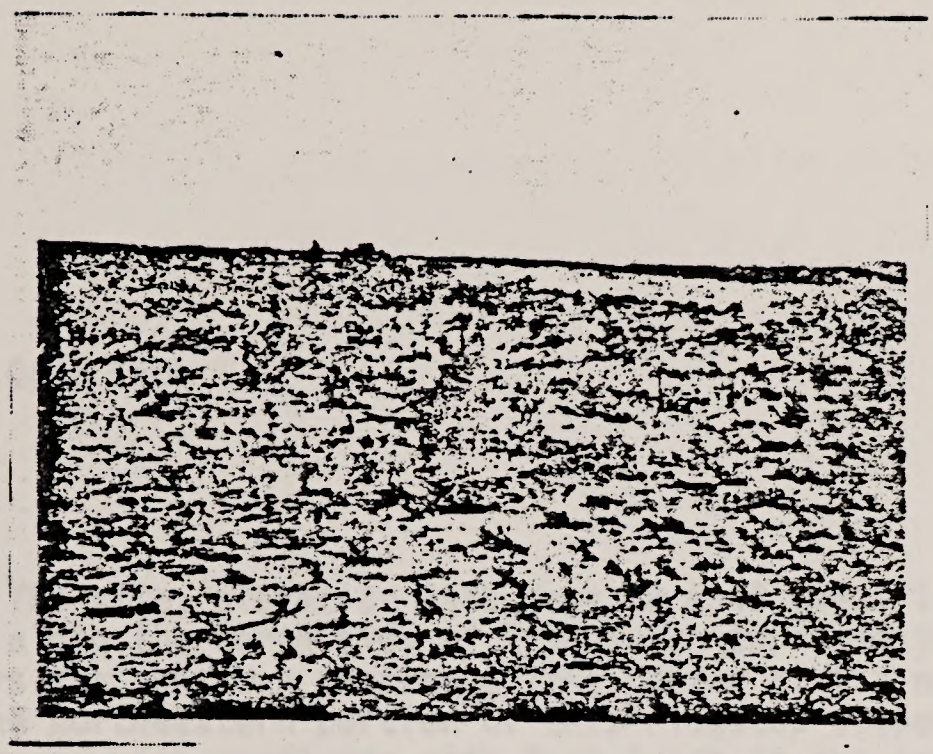


FIGURE 9. 5RB317, general view from the east. The site is in the foreground.

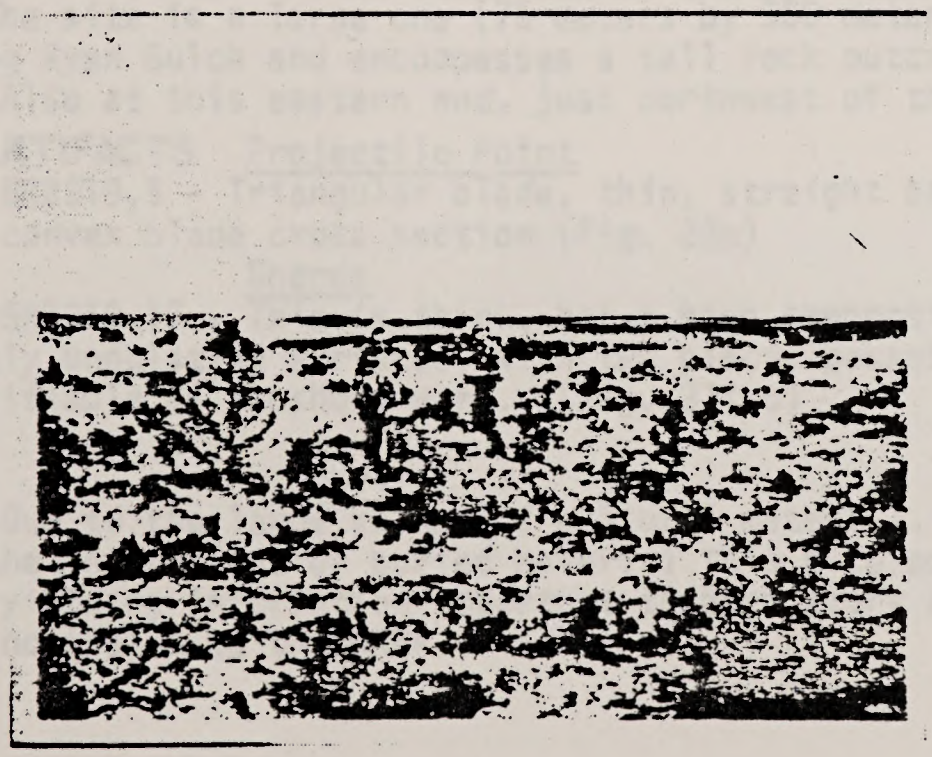
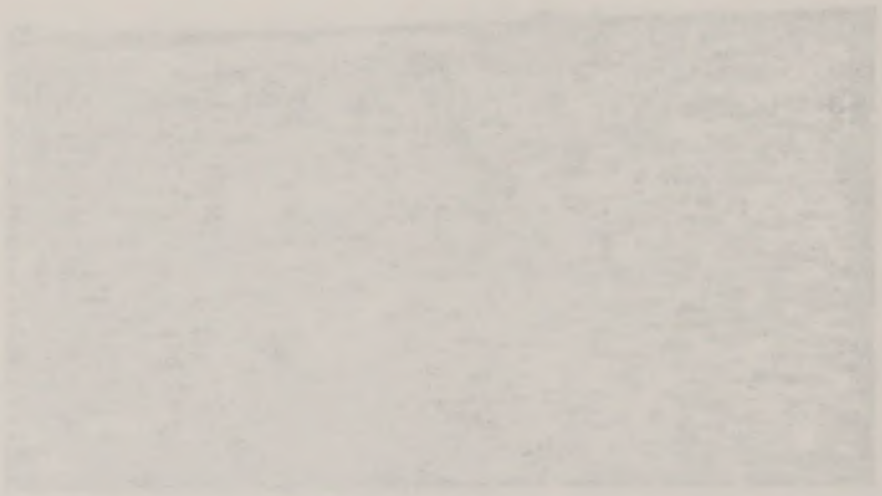


FIGURE 10. 5RB318, general view from the north. The crew is on the site.





SITE 5RB319 (Fig. 5,11,12,13,14, 15)

LOCATION

TYPE: Open Camp

DESCRIPTION The site, elevation 6460 feet to 6545 feet, is on a ridgetop which follows along the north side of Ryan Gulch approximately 100 meters away. The site covers the southern extreme of the center of the northwest quarter of section 6. The northeastern portion of this ridgetop slopes down to an unnamed seasonal drainage which confludes with Ryan Gulch in the center of the NE¼ of section 6, 300 meters away. There is a tall sandstone outcrop at the eastern (lower) end of the site. The surrounding vegetation is a mixture of pinon-juniper, rabbitbrush (*Chrysothamnus*, sp.), lupine (*Lupinus*, sp.), Opuntia, crested wheat (*Agropyron*, sp.), wild onion (*Alluim*, sp.), mountain mahogany (*Cercocarpus*, sp.), serviceberry (*Amelanchier*, sp.) and local grasses. The site affords an excellent view for many miles in both directions along Ryan Gulch and includes the confluence of Ryan Gulch and Piceance Creek. The view to the northwest up the ridge is restricted. The site is a large one (75 meters by 550 meters) lying on a ridge-top overlooking Ryan Gulch and encompasses a tall rock outcrop at the eastern end of the site. Also at this eastern end, just northwest of the tall rock outcrop (cont.

DIAGNOSTIC ARTIFACTS Projectile Point

5RB319.5 - Triangular blade, thin, straight base, straight stem, concave-convex blade cross section (Fig. 23e)

Sherds

5RB319.17 - This is thick, has a high proportion of crushed rock temper, strongly undulating surfaces, with two pieces possessing a brushed surface finish. Classifiable as Shoshoni ware. (Fig. 23i-o)

EVALUATION Due to the large volume of cultural material, the presence of features and the indications of buried material this site possesses sufficient potential for yielding information important to prehistory at the state level and should be nominated to the NRHP.

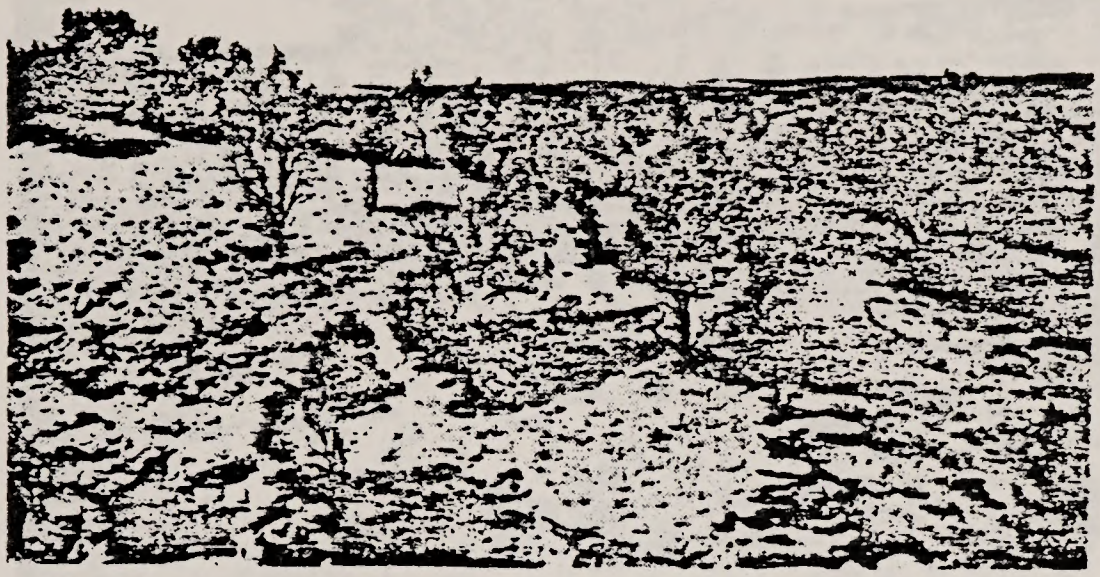


FIGURE 11. 5RB319, General View from the Northwest.. This photo was taken from the top of the rock outcrop. David Hall is standing in the Teepee ring in the center of the photograph.



FIGURE 12. 5RB319, General View from the East. The site is on the ridge-top in the photograph. The rock outcrop on which Features 2 and 3 are located is in the far left of the photograph.







FIGURE 13. 5RB319, Feature 1, View from the South. David Hall and Gayle King are on the eastern edge of the Teepee ring.

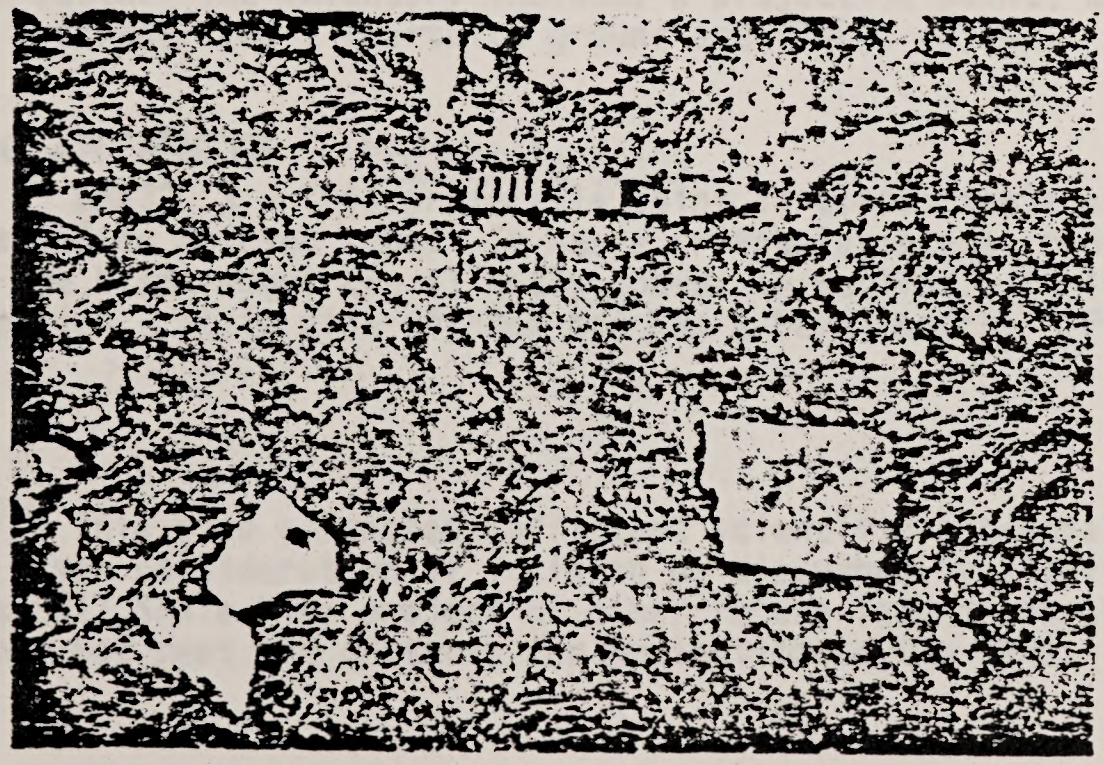
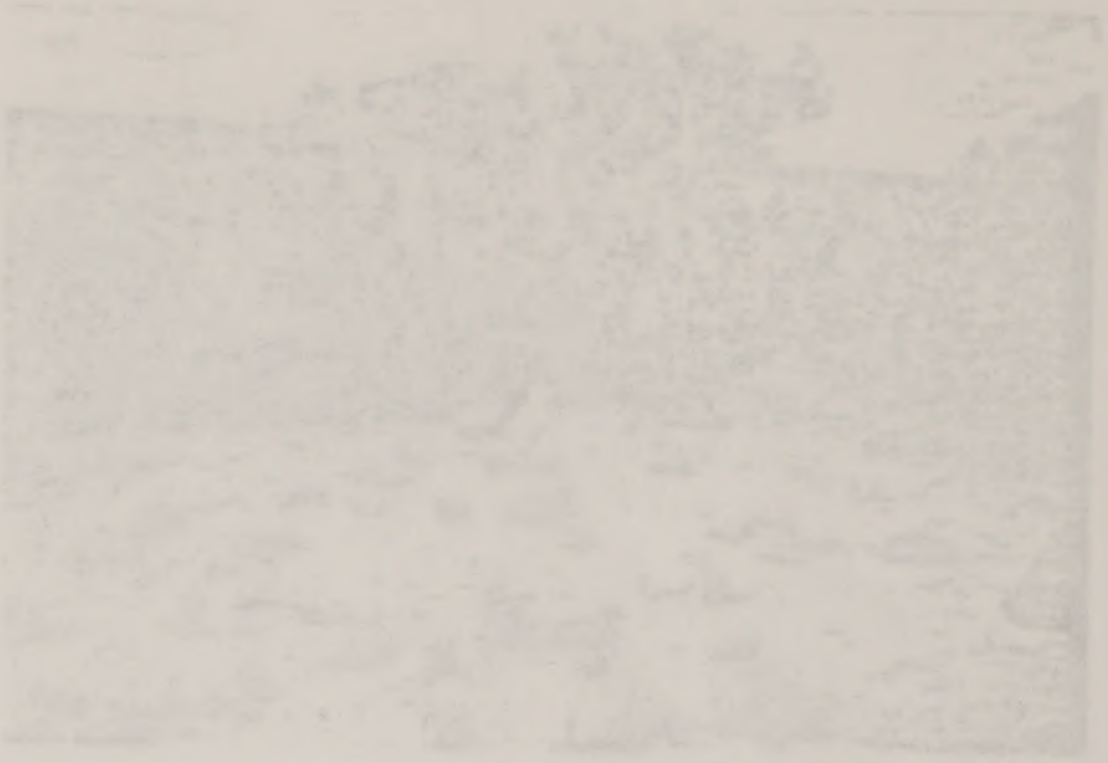


FIGURE 14. 5RB319, Feature 2, Firepit in Center of Photo.





SITE 5RB320 (Fig. 16)

LOCATION

TYPE: Open Camp

DESCRIPTION The site, elevation 6560 feet, is on a north-south running ridge along a southeast running drainage that flows into Ryan Gulch approximately 1600 meters to the southwest. Approximately 200 meters to the southeast is the confluence of the drainage bounding the ridge. The ridge runs nearly parallel to the section line bounding section 31 on the east. The vegetation consists of pinon-juniper with some sage (*Artemisia*, sp.), rabbit brush (*Chrysothamnus*, sp.) and native grasses.
The site consists of a thin lithic scatter along a ridge, in an L shape following the contour of the ridge. There are two hearth areas on the ridge-top near the southern end. This southern end stops at an abrupt dropoff and some sandstone outcroppings on the end of the ridge give a good view of the area to the south. The inventory includes a projectile point, two biface fragments, a scraper and a quartzite ground and flakes object.

DIAGNOSTIC ARTIFACTS Projectile Point

5RB320.3 - This projectile point is classifiable as a variant of the Desert Side Notched type. It has a triangular blade, medium breadth to length, the blade edges are slightly convex in outline. It is lenticular in cross section. It is side notched and has a basal notch. (Fig. 23f)

EVALUATION This site possesses sufficient scientific potential to recommend that it be given consideration if it is to be disturbed by a revision of the Experimental Oil Shale Mine project or other future land disturbing operations. The site does not meet the criteria for nomination to the NRHP.



FIGURE 15. 5RB319, Feature 3, Firepit in Center of Photo.



FIGURE 16. 5RB320, General View from the East. The site is in the foreground. Note that this area has been chained and is now subjected to erosion.





SITE 5RB321 (Fig. 17)

LOCATION

TYPE: Open Lithic

DESCRIPTION The site, elevation 6520 feet, is on a small spur ridge trending south-southwest and bounded on the north by the rim of a primary ridge system. Both to the east and west is the head of an unnamed drainage descending southwest into another unnamed drainage. The ridge is 1600 meters northwest of the confluence of Ryan Gulch and this unnamed drainage.
The vegetation is predominately pinon-juniper, sage (*Artemisia*, sp.), rabbit brush (*Chrysothamnus*, sp.) and local grasses.
The lithic scatter is very thin in the 37 meter by 49 meter site area. This fact is probably due to chaining. The inventory includes two projectile point fragments, two utilized flakes, and assorted flakes.

DIAGNOSTIC ARTIFACTS

None

EVALUATION This site possesses scientific value which would warrant its being considered for salvage if endangered by land disturbing development. However, it does not meet the criteria for nomination to the NRHP.

SITE 5RB322 (Fig. 18)

LOCATION

TYPE: Open Lithic

DESCRIPTION The site, elevation 6500 feet, lies in a basin between two small rises at the head of a drainage running 200 meters southeast to Ryan Gulch. The vegetation consists of sagebrush (*Artemisia*, sp.), rabbit brush (*Chrysothamnus*, sp.), Opuntia, native grasses and two juniper trees. There are some juniper and a few pinon to the northeast. The view to the east, south and west is relatively open, however the rise to the north must be mounted for an adequate view to the north.

The site consists of a 20 meter by 20 meter area with a very thin lithic scatter of one flake, one utilized flake and one chopper.

DIAGNOSTIC ARTIFACTS

None

EVALUATION This site has the potential for providing information of scientific value, but does not meet the criteria of importance and should not be nominated to the NRHP. If directly endangered by future development of the area, 5RB322 should be re-evaluated for the purpose of determining whether or not it should be salvaged.



FIGURE 17. 5RB321, General View from the North. Michael Spitzer is in the center of the site.



FIGURE 18. 5RB322, General View from the North. The site is in the foreground. The brunton and tripod mark the datum. From left to right - Gayle King, David Hall, Linda Spitzer and Kevin Jones.





SITE 5RB323 (Fig. 19)

LOCATION

TYPE: Open Camp

DESCRIPTION The site, elevation 6480 feet, is on the top of a northeast trending ridgetop dropping off into Horse Draw, 800 meters northeast. The ridge is bounded on both east and west by a seasonal drainage. The west drainage shows as a blue line feature on the USGS.
The vegetation consists of pinon-juniper, sagebrush (*Artemisia*, sp.) and local grasses.
The view of the Horse Draw area to the east, north and west is relatively unrestricted. This is a small site with the primary flake concentration and tool distribution in a 20 meter diameter area on the crest of a ridge. The one flake concentration is a stain with charcoal flecks and burnt bone which appears to be a hearth. The inventory includes a biface fragment, utilized flakes, one pipe fragment, one core and flakes.

DIAGNOSTIC ARTIFACTS
None

EVALUATION This site has the potential for providing information important to prehistory at the state level and should be nominated to the NRHP.

SITE 5RB324 (Fig. 20)

LOCATION

TYPE. Open Lithic

DESCRIPTION The site, elevation 6200 feet, is located on two east-facing ridges jutting out toward Piceance Creek on the west and lies between Ryan Gulch to the south and Horse Draw to the north. The ridge is one of a series of fingers divided by small drainages that are flowing east to Piceance Creek approximately 400 meters east. The ridgetops are unprotected, susceptible to the wind and are infested with mosquitos.
The vegetation consists of low sagebrush (*Artemisia*, sp.), rabbit brush (*Chrysothamnus*, sp.), local grasses and juniper in the drainages.
The site consists of a thin scattering of lithic material on the north-facing slope of one ridge just below the crest and a scraper on the next ridge north approximately 130 meters from the datum. Five of the seven artifacts were of the same smoky-dark chert and were found clustered in a three meter diameter circle along with flakes of the same material. The main concentrations of artifacts occurred on the northern slope of the ridge, just over the crest. When strong winds blow from the south, this location provides
DIAGNOSTIC ARTIFACTS protection. The inventory includes four utilized flakes, three scrapers and assorted flakes.

None

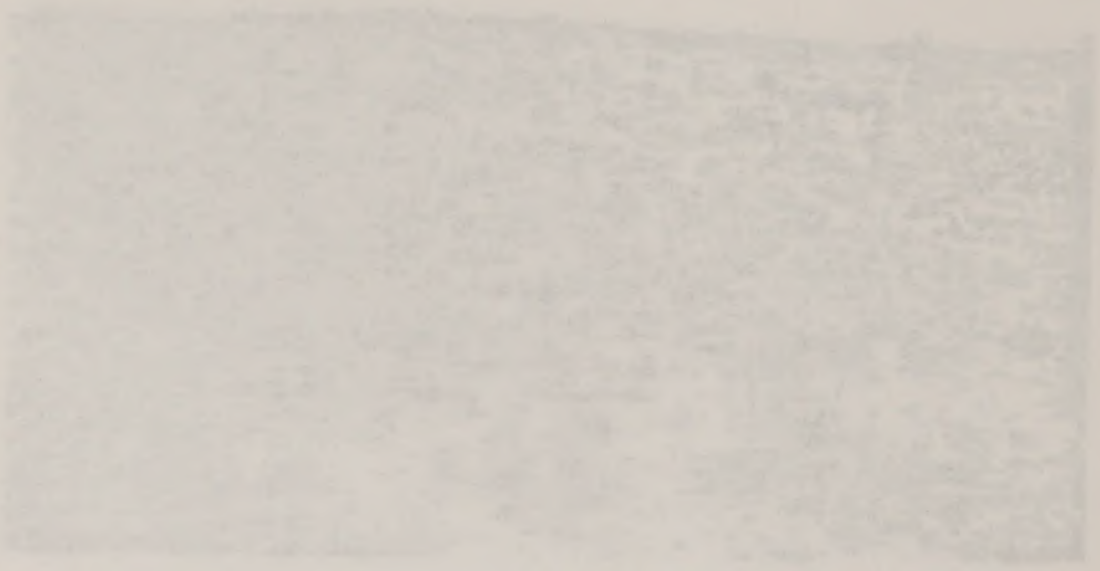
EVALUATION This site has no potential for providing information important to prehistory and should not be nominated to the NRHP. The site also has little potential for providing useful ancillary scientific information. No further action is necessary with regard to 5RB324.



FIGURE 19.. 5RB323, General View from the North. The compass and tripod mark the datum. From left to right - Linda Spitzer, David Hall and Kevin Jones. Note the extensive disturbance caused by chaining.



FIGURE 20. 5RB324, General View from the Northwest. Arrow indicates site location. The Piceance Creek flood plain runs left to right through the center of the photograph.





SITE 5RB325 (Fig. 21)

LOCATION

TYPE: Open Lithic

DESCRIPTION The site, elevation 6320 feet, is on a saddle and accompanying spur ridge trending northwest from a larger ridge system to the west. The said ridge overlooks Piceance Creek 900 meters east. The primary ridge trends northwest to the confluence of Horse Draw 1000 meters away.
Onsite vegetation consists of sage (*Artemisia*, sp.) and local grasses. Approximately 300 meters west and 400 meters south are pinon-juniper groves.
The site, 50 meters by 150 meters, consists of a scattered distribution of lithic material in the saddle and on the top of the spur ridge. The inventory includes projectile point tips, one mano fragment, utilized flakes, scrapers and assorted flakes.

DIAGNOSTIC ARTIFACTS

None

EVALUATION This site has no potential for providing information of scientific value for local, state and regional prehistory and should, therefore, not be nominated to the NRHP. 5RB325 does have apparent potential for yielding useful ancillary information on the region's prehistory and should be considered for salvage prior to its destruction if ever endangered by future developments.

SITE 5RB326 (Fig. 22)

LOCATION

TYPE Open Lithic

DESCRIPTION The site, elevation 6420 feet, is located on an east-northeast trending spur ridge 80 feet vertically below the crest of the primary ridge system bounded by Horse Draw on the north, Ryan Gulch to the south and Piceance Creek 1000 meters to the east. The confluence of Ryan Gulch and Piceance Creek is 1000 meters southeast. That part of the spur ridge connecting with the primary ridge system forms a saddle west of the crest. From the mouth into Horse Draw and south-southeast into Ryan Gulch are drainages descending from this saddle.
The vegetation consists of pinon-juniper, sage (*Artemisia*, sp.) and local grasses.
This site, 45 meters by 120 meters, consists of a thin lithic scatter including two mano fragments, one scraper, one biface, two utilized flakes and assorted flakes.

DIAGNOSTIC ARTIFACTS

None

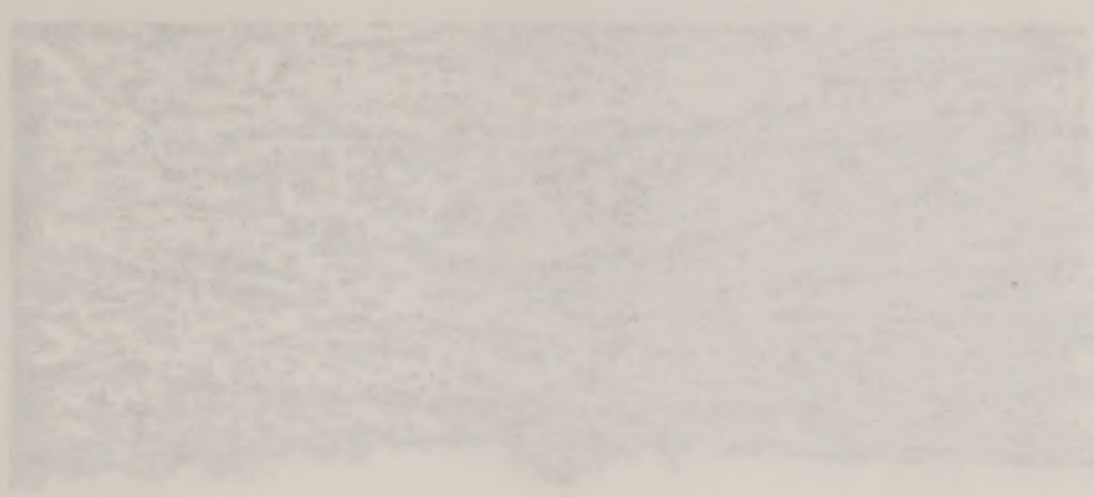
EVALUATION This site has no potential for providing information important to prehistory and should not be nominated to the NRHP. However, 5RB326 does have potential for producing useful ancillary scientific information and should be salvaged prior to any land disturbance within its boundaries.

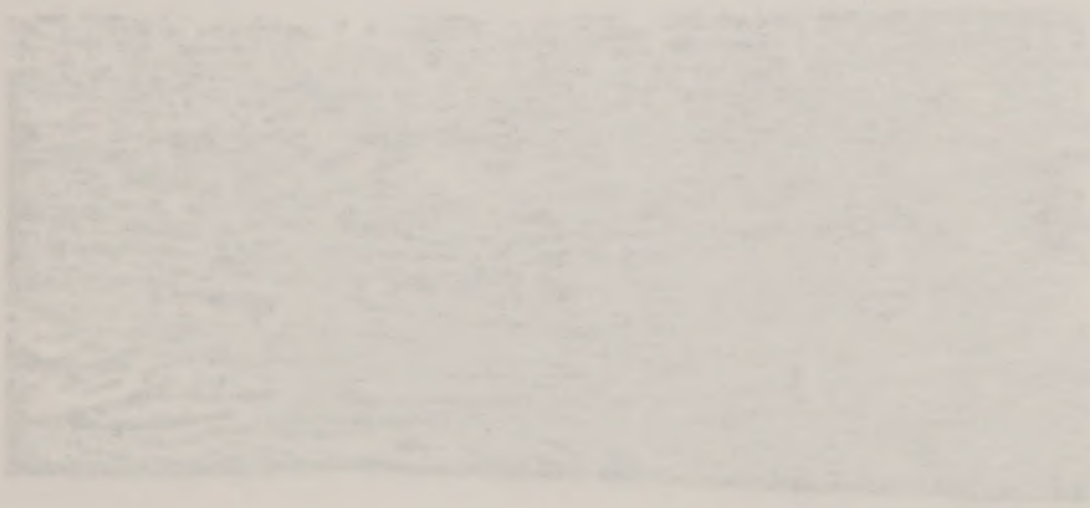


FIGURE 21. 5RB325, General View from the Southwest. The site includes the entire top of this ridge.



FIGURE 22. 5RB326, General View from the East-Southeast.





ISOLATED FINDS

Twenty-three isolated finds were located in the study area. Most of these specimens were found in localities adjacent to sites, though far enough outside of the site boundaries to justify maintaining them as isolated finds. These localities were in areas identical in most respects to their nearest site neighbors so that the isolated find distribution is in the central portion of the ridge separating Horse Draw and Ryan Gulch or immediately adjacent to the drainages.

Included in the isolated finds were two projectile points, three bifaces, two scrapers, one drill, one chopper-pounder and two groundstone tools.

Projectile Points

Isolated Find 64. (Fig. 23a)

This projectile point was found in the bottom of Horse Draw in the SE¼ NE¼ SW¼, Section 30, T1s, R97w. Because of its location this projectile point may have washed in from upstream or any number of adjacent ridges.

I.F. 64 is complete with the exception of not more than two mm of the tip. It is convex in cross section on one side and the other is partly convex with a concavity formed by flake detachment from the core. It has a triangular blade with slightly convex edges, corner notches which are nearly perpendicular to the long axis of the point, and a slightly convex base.

Comparison with other areas indicates that this point type is widely distributed. In nearby Dinosaur National Monument, this type was found in several different pre-ceramic or pre-Fremont contexts (Breternitz

This fragment is a midsection of either a large biface or a rather large projectile point. Composed of orange-brown quartzite, this tool has straight edges and is triangular.

This tool has no useful diagnostic features.

Isolated Find 75. (Fig. 24b)

This tool is a biface fragment found on a bench overlooking the Piceance Creek floodplain in NE¼ SW¼ NE¼, Section 31, T1s, R97w.

It is made of a grainy red quartzite with most of the thinning flakes taken off of the dorsal face and lacks chronologically diagnostic attributes.

Isolated Find 68. (Fig. 25a)

This tool is a distal end scraper located on the end of a ridge formed by the fork of the head of an unnamed seasonal drainage in NW¼ SW¼ NW¼, Section 31, T1s, R97w.

The distal end and portions of the lateral margins are unifacially retouched on the dorsal face and have step scarring associated with scraping on "hard" materials such as wood and bone.

Generally, scrapers of this type, which require greater labor input, are associated with archaic materials, although this does not yield a definitive time range.

Isolated Find 73. (Fig. 25b)

This scraper was located in a juniper grove on the crest of a southeast trending ridge terminating on the Piceance Creek floodplain 400 meters away. Its location is SW¼ NE¼ SE¼, Section 31, T1s, R97w.

This tool, made of brown chert, is a very thick flake which abruptly terminated at the distal end and has been unifacially retouched along both dorsal, lateral margins. The use wear is also unifacial and along the lateral edges on the dorsal side inside of the retouch scars.

There are no attributes diagnostic of temporal association.

Isolated Find 76. (Fig. 23p)

This specimen is a drill of beige and grey chert located on a bench above the floodplain of Piceance Creek in SE¼ NW¼ NE¼, Section 32, T1s, R97w.

This drill is bifacially retouched with the tip and a portion of one side of the bit missing.

Drills such as these currently lack attributes diagnostic of chronology.

Isolated Find 78.

This tool is a shale chopping-pounding tool found on a bench above the Piceance Creek floodplain in SE¼ SW¼ SE¼, Section 29, T1s, R972.

One face of this chopper-pounder has large thinning scars while the other is unmodified. The edge on one end of the long axis possesses battering scars.

This artifact possesses no attributes diagnostic of chronology.

Groundstone Tools

Isolated Find 82. (Fig. 26a)

I.F. 82 is a subrectangular mano which was used in the processing of nuts and seeds into meal. It was found in the center of the SE¼ of Section 32, T1s, R97w.

This specimen, made of red sandstone, was intentionally prepared by shaping the sides to reach the desired shape and pecking the faces to increase the mano's abrasive qualities. One side has been ground and is highly polished while the other is pecked but is not as extensively used.

Manos like these are associated in archaic through recent periods and are not diagnostic of particular temporal ranges.

Isolated Find 74.

I.F. 74 is an oval mano found on the crest of a southwest trending ridge overlooking Ryan Gulch approximately 300 meters southwest.

One side is intentionally modified to produce its shape and one face is pecked. The other face is so badly weathered that there are no remaining indications of use.

No temporal associations are attributable to this specimen.

CHRONOLOGY

The chronology for this series of sites is unclear. Certainly this area was occupied prior to contact and judging from the possible age of I.F. 64, occupation may have extended back as far as 1250 B.C. However, one may expect that prehistoric habitation extends farther back than this. RB317.5 does in fact possess characteristics comparable if not identical to types found at Danger Cave which were in stratigraphic associations dated prior to 2000 B.C., although after 7000 B.C.

The latest datable material is the Shoshoni Ware found at RB320. The dates on this style range from protohistoric through historic times.

Based on this rather scanty evidence it may be surmized that this region was occupied from at least 2000 B.C. to the present. This offers considerable value for potential culture change studies.

The buried nature of many of the sites offers additional potential evidence of extended occupation. Apparently the soil on the sites is now eroding, leaving behind the concentrations of sandstone and shale

observed on most of the sites. This is partially responsible for the exposure of artifacts. Furthermore, the cultural material being brought to the surface by ants on these same sites indicates buried components. Only testing can help determine the extent and nature of these sites.

INTERPRETATION

The interpretive aspects of this project are restricted to two essential areas of concern. One is the location of prehistoric sites in the study area and the other is an evaluation of the chronological depth represented by archaeological resources observed and collected. This latter goal depends upon both geological information and as yet, poorly understood artifact styles applicable to this region.

The quantity and nature of the information collected holds enticing prospects for the archaeologist at an intuitive level, however, well-documented empirical evidence for the construction of cultural chronology, reconstruction of lifeways and processual studies is lacking. This is principally a result of three factors. One is that a number of the sites are small and correspondingly yield small amounts of surface material. Secondly, some sites have been extensively disturbed on the surface by chaining activities. Artifacts which would otherwise be observed are buried in disturbed soil or covered by dead vegetation. Third is the problem of relic hunters who collect artifacts from the surface which are most valuable archaeologically for establishing chronology. This is especially noticeable for 5RB319. A wide variety of materials was found but the quantities were small. There was distinct evidence of visitation by recent historic people in the form of pop-top aluminum cans and cigarette butts.

As noted above, the evidence for the construction of identification of chronology is scanty at best, however, with the appropriate limitations in mind, the regional sequence appears to extend from at least 2000 B.C. to the present. The value of establishing or even extending this is unquestionable. Such an understanding requires at minimum the testing of several sites to obtain and correlate stratigraphic sequences both at the geologic and cultural level.

In addition to aiding the construction of chronology, a responsible testing program might also provide information concerning subsistence and procurement activities in the region and lead to processual studies, given sufficient time depth.

RECOMMENDATIONS

None of the sites located in the archaeological reconnaissance of the proposed Bureau of Mines Experimental Oil Shale Mine Project are endangered by the development as planned. Disturbance of the surface is to be concentrated in the SW¼ of Section 29 and the SE¼ of Section 30, T1s, R97w. No sites were found in the latter area and only two in the former. Both of the sites in the SW¼ of Section 29 are well removed from the vicinity of the shale storage area, the nearest project feature, and are in no way endangered (Fig. 2).

National Register of Historic Places Nominations

Only two sites, 5RB319 and 5RB323 have been recommended for nomination to the NRHP. As noted in the discussions of the two sites, they possess apparently high potential for yielding information important to prehistory at least at the regional level. It should be noted that no

activity with even the slightest potential for disturbing the surface of the sites can be allowed in their immediate vicinity until final determination of their status with regard to the NRHP is made. These sites are well away from the areas immediately slated for development and should in no way be affected in the near future.

Sites with Scientific Value

Eight sites with potential for providing scientific information, but not of significant importance to prehistory, are located within the project boundaries. These sites, 5RB310, 316, 317, 320, 321, 322, 325, and 326, would provide information supplemental to that yielded by 5RB319 and 323 increasing the importance of these two sites to prehistoric studies in Colorado. Consequently, we have recommended that in the event any or all of these eight sites are endangered by changes in development plans or other future activities within the study area, salvage operations be carried out to recover at least a sample of their informational content. This recommendation is made on the grounds that the sites are protected from destruction by the Antiquities Act of 1906 even though they are not worthy of consideration for nomination to the National Register of Historic Places.

Paleontological Site

Site 5RB320 also produced indications that it may have paleontological values as well as archaeological information. As archaeologists, we lack the proper training and professional qualifications to properly evaluate the importance of the paleontological resources of 5RB320 and urge that a qualified paleontologist examine and evaluate this dimension of the site. The staff of the University of Colorado Henderson Museum includes qualified individuals with direct experience with Piceance Creek Basin paleontology.

Sites Requiring No Further Action

Only two sites, 5RB318 and 324, require no further consideration in regard to cultural resource management. These sites have no indication that they provide either useful ancillary scientific information further enhancing the importance of 5RB319 and 323 or information important to regional, state, or national prehistory. In this light, then, it is felt that the information most useful to furthering our understanding of Colorado's prehistory has already been collected as the result of the reconnaissance project and any other work on the sites will prove fruitless.

SUMMARY

This archaeological reconnaissance was conducted under contract with the Bureau of Mines for the purpose of locating cultural resources which face potential disturbing factors due to construction and mining activities associated with the Bureau of Mines Pilot Oil Shale Mine. The field work was conducted in a systematic, intensive manner and sites were recorded and collected likewise. All artifacts were returned to the Laboratory of Public Archaeology for storage.

A total of 12 sites and 23 isolated finds were located in the course of the survey. There was a yield of a wide range of artifacts and features, but none of these were of undoubted value for chronological evaluation, with the exception of two projectile points and 10 potsherds identified as Shoshoni ware.



FIGURE 23. Projectile Points and Potsherds. Left to right: row 1 (a) IF64RB, (b) RB316.3 (c) RB316.4, (d) RB317.5. row 2 (e) RB319.5, (f) RB320.3, (g) RB321.2, (h) RB321.4. row 3 (1) RB319.17, (j) RB319.17, (k) RB319.17, (l) RB319.17. row 4 (m) RB319.17, (n) RB319.17, (o) RB319.17, (p) IF76.





FIGURE 24. Bifaces. Left to right: row 1 (a) IF62, (b) IF75, (c) IF77, (d) RB310.11. row 2 (e) RB317.1, (f) RB319.19, (g) RB320.6, (h) RB320.11. row 3 (i) RB320.9, (j) RB321.8, (k) RB323.11, (l) RB325.7. row 4 (m) RB325.2. (n) RB325.4, (0) RB325.28, (p) RB326.12.





FIGURE 25. Scrapers. Left to right: row 1 (a) IF68, (b) IF73, (c) RB310.16. row 2 (d) RB323.6, (e) RB323.8, (f) RB323.9. row 3 (g) RB325.20 (h) RB325.21.



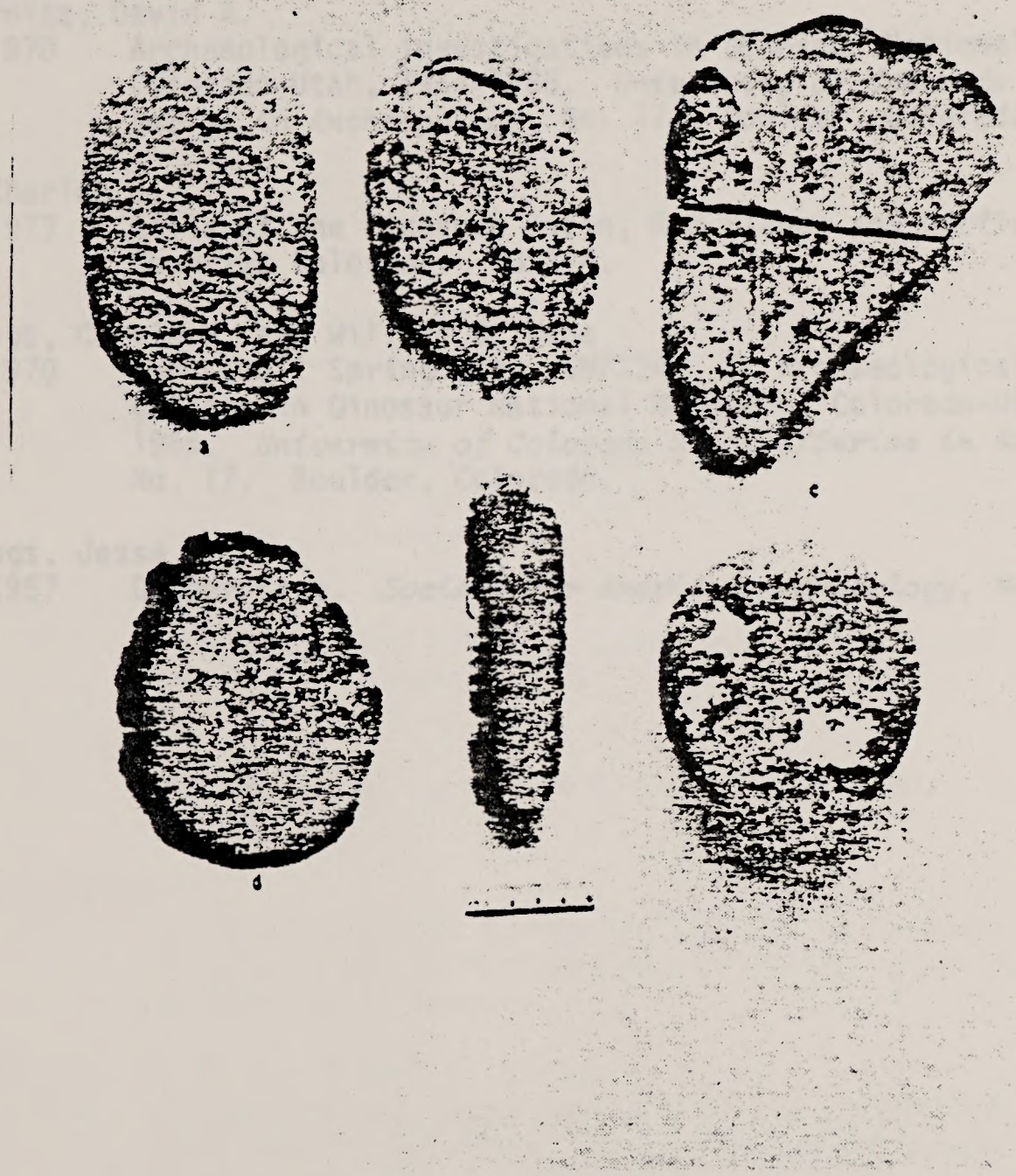
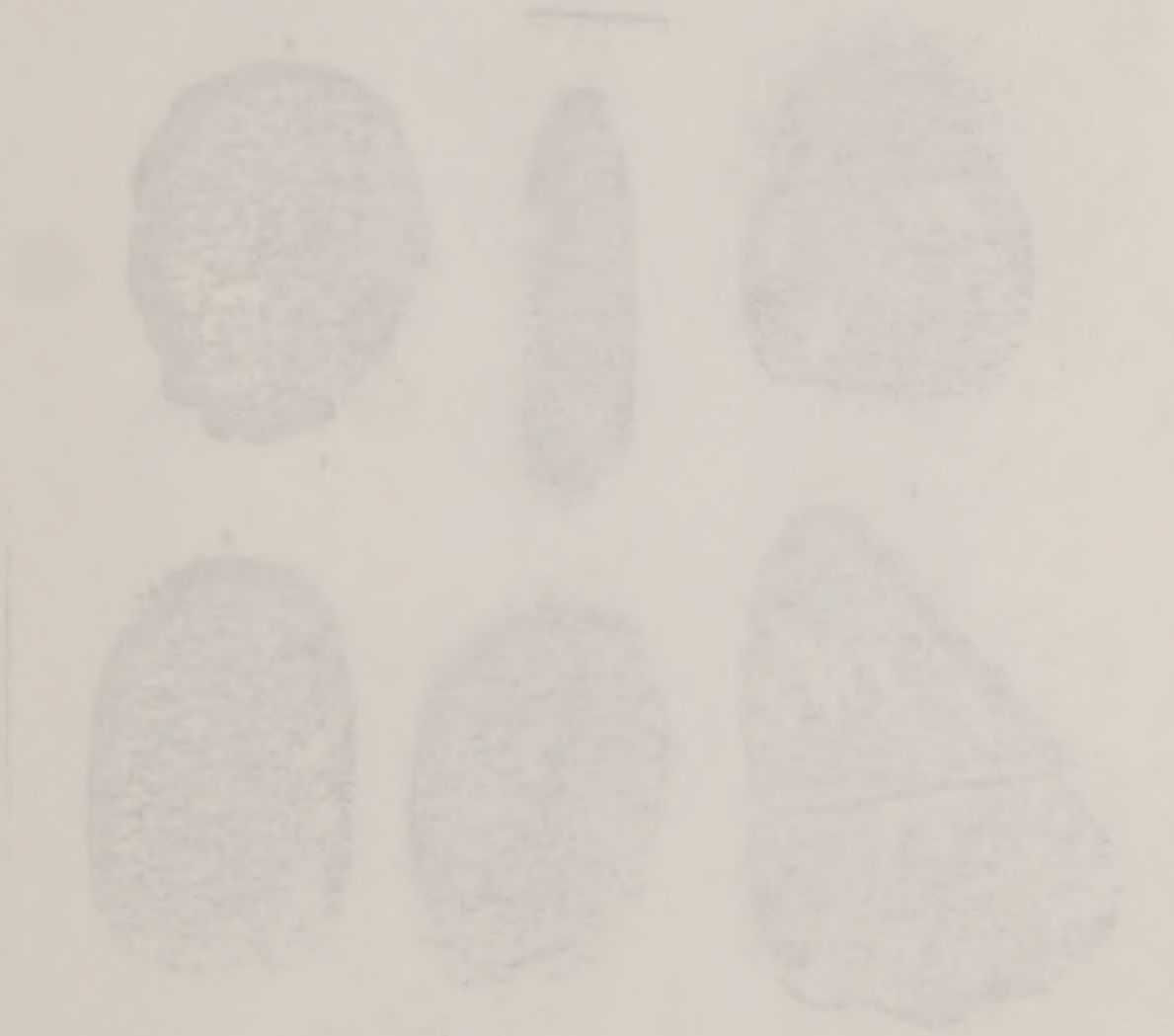


FIGURE 26. Representative Groundstone. Left to right: row 1 (a) IF82, (b) RB319.18, (c) RB321.10. row 2 (d) RB325.19, (e) RB326.4, (f) RB326.5.



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APPENDIX 11D

SUMMARY DESCRIPTION AND EVALUATION OF THE PALEONTOLOGICAL RESOURCES

Site Number	Geological Period & Formation	Types of Resources	Condition of Preservation	Level of Importance
Vertebrate				
V_1	Uinta 5	Brontothere tooth + bone fragments	Moderate	III
V_2	Uinta 5	Bone fragment	Poor	IV
V_3	Uinta 5	Brontothere Skull, not collected	Moderate	I
V_4	Uinta 5	Brontothere Skull, not collected	Moderate	I
V_5	Uinta 5	Foramen Magnum	Poor	IV
V_6	Uinta 5	1) Teeth in rock, not collected 2) Isolated tapiroid tooth	Moderate	III
V_7	Uinta 5	Limbbone, not collected	Good	III
V_8	Uinta 5	Limbbone, not collected	Good	III
V_9 (1)	Holocene (recent)	Bison (Bison bison) Skull	Poor	IV
Invertebrate				
I_1	Uinta 4	Insect larvae	Good	III
Paleobotanical				
P_1	Uinta 4	Fossil Plants	Poor	IV
P_2	Uinta 4	Fossil Plants	Poor	IV

APPENDIX 11D (Cont.)

SUMMARY DESCRIPTION AND EVALUATION OF THE PALEONTOLOGICAL RESOURCES

Site Number	Geological Period & Formation	Types of Resources	Condition of Preservation	Level of Importance
P_3 (1)	Uinta 4	Fossil Plants	Poor	IV
P_4 (1)	Uinta 5	Fossil Plants	Good	I
P_5 (1)	Uinta 5	Fossil Plants	Good	I
P_6	Uinta 4	Fossil Plants	Poor	IV
P_7	Green River 13m. Creek tongue	Fossil Plants	Poor	IV
P_8 (1)	Green River 13m. Creek tongue	Fossil Plants	Poor	IV
P_9	Green River 13m. Creek tongue	Fossil Plants	Poor	IV
P_{10}	Uinta 5	Fossil Plants	Poor	III
P_{11}	Uinta 4	Fossil Plants	Poor	IV
P_{12}	Green River 13m. Creek tongue	Fossil Plants	Poor	IV

(1) Outside Project Area

PALEONTOLOGICAL RESOURCES INVENTORY AND EVALUATION, BUREAU OF MINES EXPERIMENTAL OIL SHALE MINE, RIO BLANCO COUNTY, COLORADO

Prepared for:

VTN Colorado, Inc.
2600 S. Parker Rd.
Paker Place Four
Aurora, CO 80014

Prepared by

Dr. Peter Robinson
Paleontological Associates
550 Hartford Drive
Boulder, CO 80303

August 1978

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I. Introduction

A. Abstract

1. Findings

Three geologic units, of Eocene age, crop out in the 2600 acre area of the experimental mine. These are tongues 4 and 5 of the Uinta formation and the Thirteen Mile Creek Tongue of the Green River formation. All are found to contain fossils but the most valuable material was found in Tongue 5 of the Uinta Formation. In this unit medium to large size fossil mammals occur episodically.

2. Impacts

The greatest impacts may be to surface exposures of Tongue 5 if project impacts occur in these areas. Possible impact from personnel is considered.

3. Recommendations

It is recommended that all known surface finds of fossil vertebrates be salvaged if these areas are to be impacted.

B. Identification of Responsible Parties

1. Sponsor

VIN Colorado, Inc.

2. Principal Investigator

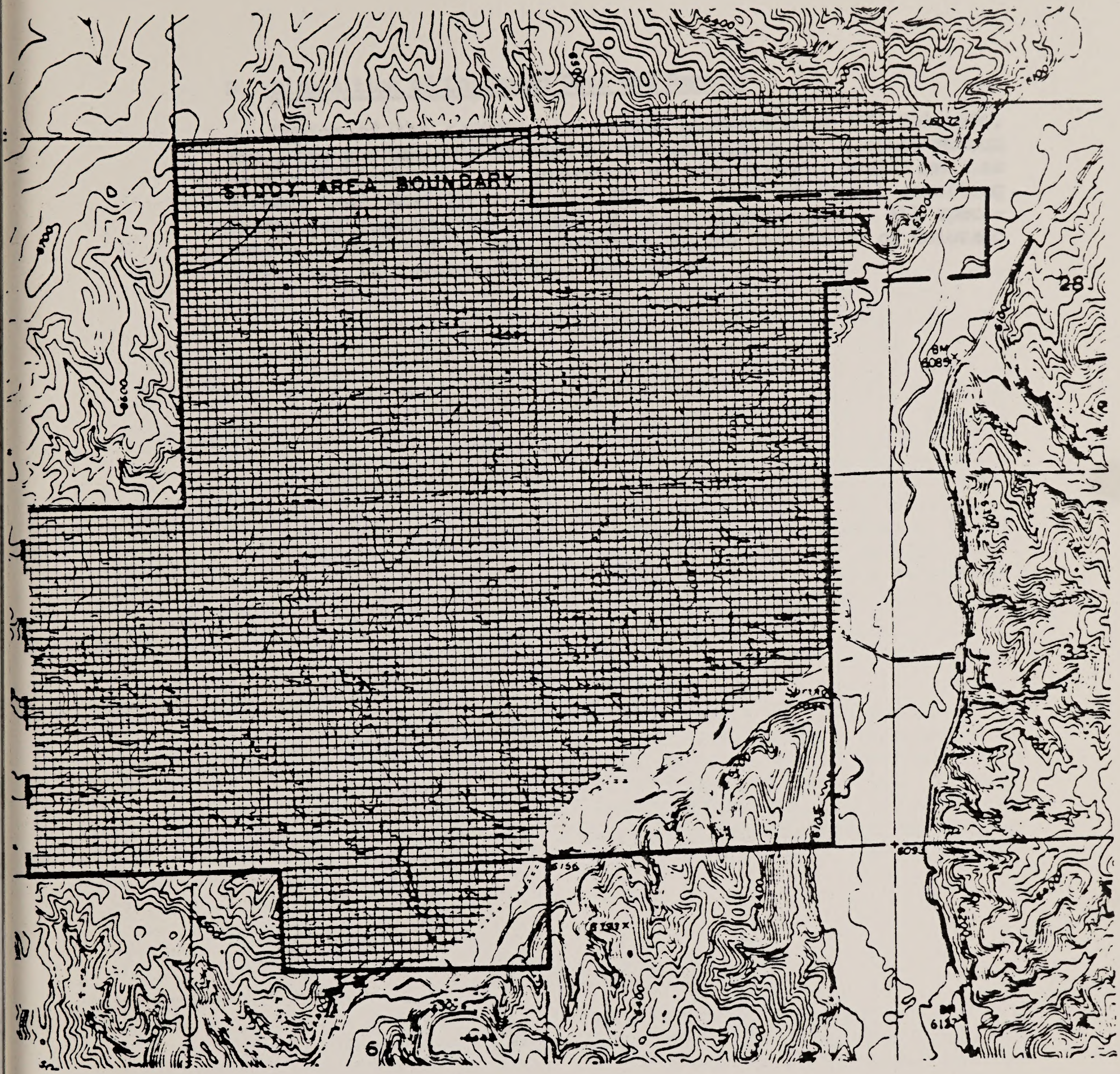
Peter Robinson, Ph.D. (Yale), President, Paleontological Associates, Inc., Boulder, Colorado, and Director, University of Colorado Museum.

3. Government Agency Contacts

Peter Robinson holds a valid permit to collect fossils on BLM land in Colorado. This permit expires 31 December 1978.

C. Location of Study Area

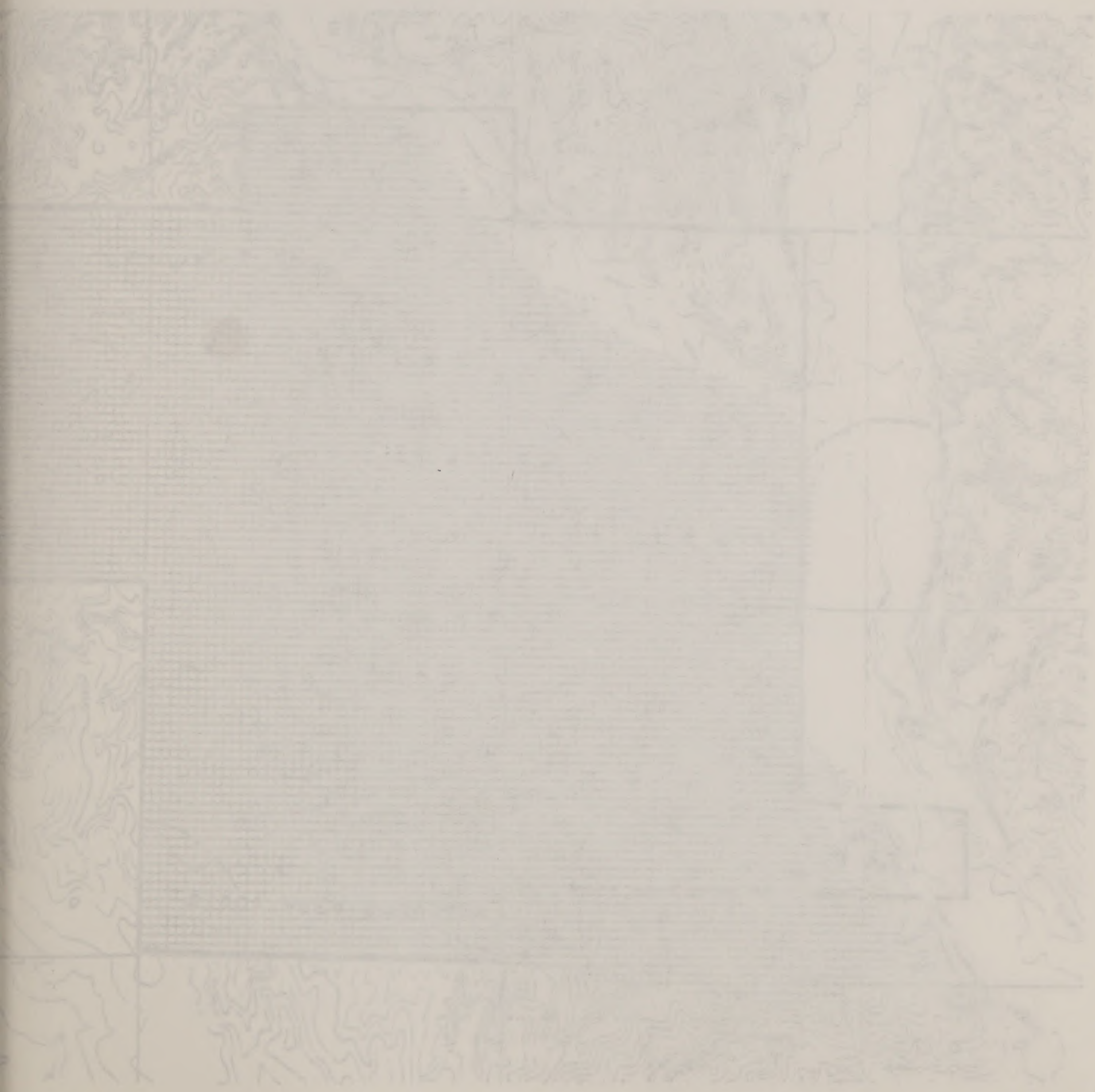
The area is located in the Piceance Creek basin, Rio Blanco County, Colorado, in all or parts of Sections 28, 29, 30, 31, 32, T.1S, R.97W, Section 36, T.1S, R.98W, and Section 6, T.2S, R.97W (see Figure 1).



Area covered by survey

PALEONTOLOGICAL STUDY AREA
SCALE: 1" = 2000'
CONTOUR INTERVAL: 20'

FIGURE 1



D. Disposition of Collected Data and Reports

Copies of the reports are in the possession of VTN Colorado, Inc., and the Geologic Section of the University of Colorado Museum -- EIS Collection. The presence of the fossil localities has already been made known to the BLM as a part of normal reporting procedures required by holders of collecting permits. All specimens collected are in the Collections of the University of Colorado under the field number PA-16 + sub-number.

II. Methods

A. Data Collection Methods

1. Non-field

a. Literature Review

A search was made of the Bibliography of Fossil Vertebrates for North America (several volumes covering the years 1789-1972) for records of vertebrate fossils from Rio Blanco County. Several such records were found, but none from the project area. The Bibliography and Index of Colorado Geology was also searched, with equivalent results. Records in that volume are complete up to 1975.

Most of the references to the fossil vertebrates from Rio Blanco County are restricted to reviews of particular genera or families in publications about fossils of Eocene age. They must, therefore, be searched out by thumbing the pages of such publications for specimens referred to Rio Blanco County. A.E. Wood's monograph on the extinct rodent family, Paramyidae, is typical of the available references. Those articles found to contain Piceance Creek basin material are listed in the Bibliography.

b. Site Survey File Review

We know of no site survey file for the project area. We have found all the localities that are represented by Eocene specimens in the collections of The Museum of Western Colorado, Grand Junction; The Field Museum, Chicago; The Carnegie Museum, Pittsburgh; The University of Colorado Museum, Boulder; The Denver Museum of Natural History, Denver; and The U.S. Geological Survey, Denver Office.

2. Field

a. Survey Techniques and Intensity

Three teams of three people each covered on foot the area shown in Figure 1 on foot. The teams were supervised by Allen J. Kihm, M.S.; Michael Middleton, M.S.; and Dan Adams, M.A.; and were under the overall supervision of Peter Robinson, Ph.D. All exposures in the area were prospected for fossil occurrences. Test holes were dug at intervals, particularly in the Thirteen Mile Creek tongue of the Green River formation. Sandstone exposures of the Uinta formation tongues 4 and 5 were prospected with care, particularly where they contain lenses of mudball conglomerate. Fossils are often abundant in this type of lithology.

b. Site Numbering System

All sites were serially numbered, with a separate series for fossil vertebrates (V), for intertebrates (I), and for plants (P).

c. Site Identification Criteria

Criteria for invertebrates and plants were, (1) abundance of fossils, and (2) sufficient quality to permit identification. All vertebrate sites were numbered, regardless of quality.

C. Adverse Field Conditions

1. Environmental

Snow and vegetation cover were the two most obvious adverse environmental conditions. Herbs, shrubs, and trees cover much of the area, rendering it impracticable for field surveying. Rock exposures are patchy, and often sparse.

Since fossils are part of the substrate (and not intrusive into it, as in an archaeological site), covered areas are usually barren of fossils. These areas have been spot-checked for isolated exposures, however, in spite of the extra time and effort required for looking up blind alleys and cul-de-sacs. This is especially necessary in the areas where the Uinta Formation Tongue 5 is exposed, since the sandstone lenses vary considerably in their resistance to erosion and isolated knobs of sandstone occur in these terrains.

Snow halted the field survey in November. During a reconnaissance to Rio Blanco townsite in January, we found a snow cover averaging eight inches in depth on the flats. The remainder of the study area was completed during March, 1978.

2. Social

No adverse social conditions were found.

D. Analytical Techniques

1. Specimen Classification Systems

Plants (all Angiosperms) and invertebrates (Insects) were not broken down below the class level. Vertebrates were identified down to the Family level, and were all of the Order Perissodactyla (represented in our modern fauna by horses, rhinoceroses, and tapirs). Each specimen was labelled with the P.A. job number and the site number (for example, P.A. 16 P.4 means the fourth plant site of Paleontological Associates Job

16). The specimen was then placed in the site survey collections of the University of Colorado Museum. Most specimens found are merely of "legal-proof-of-finding" quality. A few, as noted in Section III, are of research, or potential research, quality.

2. Data Evaluation

The data acquired in this survey were evaluated with regard to both current knowledge about the area and to existing gaps in that knowledge. Since the late Eocene was a time of significant faunal change in North America, good material from rocks of that age can help to improve our understanding of that change.

D. Outside Consultants

During the 1930's and 1940's, the late J. Leroy Kay of the Carnegie Museum collected from the White River area, but his material has never been published. We therefore put Dr. Leonard Krishtalka of the Section of Vertebrate Fossils at the Carnegie Museum under contract to do a specimen search, and to send us the pertinent data. These showed that Kay had collected in Rio Blanco County, but not in the project area. Dr. Krishtalka (Ph.D., Texas Tech University, 1975) is an authority on Eocene mammals.

III. Description of the Paleontological Resources

A. Theoretical Considerations

1. Previous and Current Research

The potential for significant oil shale production has stimulated extensive research in the Piceance Creek (P.C.) basin, and a correspondingly extensive bibliography has emerged. A.C. Peale of the Hayden survey first recognized the Green River group in the P.C. basin in 1876. In 1901, G.H. Eldridge noted the economic value of these "bituminous shales and limestones". D.E. Winchester, E.G. Woodruff, and D.T. Day, all of the U.S. Geological Survey, conducted field and laboratory studies of the oil shales in the decade between 1913 and 1923. W.H. Bradley made an extensive stratigraphic and paleontologic investigation of the Green River formation in 1924-25. Since these pioneering studies, both government and industrial geologists have carried on further research with increasing frequency, adding depth and detail to the earlier foundations. The U.S. Geological Survey has completed large scale (1:24,000) geologic mapping of most of the northern portion of the P.C. Basin. Map MF-754 in this series covers the Square S. Ranch Quadrangle, which contains the Horse Draw site.

No detailed study of the fossil vertebrates of the P.C. basin exists, although scattered finds have been recorded, two of which are currently in the University of Colorado Museum. These are a jaw from a small, mongoose-like mammal of the family Miacidae in the order Carnivora, and a femur from a ponderous, odd-toed, subungulate mammal of the family Uintatheridae in the order Dinocerata.

2. Principal Investigator's Research

Dr. Peter Robinson has made many contributions to the knowledge of Eocene paleontology and stratigraphy in the Rocky Mountain region since he began work in this field in 1949. His field work has taken him to the Uinta basin in eastern Utah, and to the Rifle-Silt area, both peripheral to the P.C. basin. The present study is his first in the P.C. basin itself. The results of this survey are significant enough, in his opinion, to warrant extensive paleontological investigation within the basin (see Section III.D, below).

B. Regional Context of Study Area

1. Chronological Sequences

Not applicable to the paleontological survey.

2. Types

Not applicable.

3. Environmental Factors

a. Geology and Soils

The P.C. basin is a sub-elliptical, asymmetrically downwarped region of the Earth's crust, whose axis trends northwest-southeast, and whose dimensions are approximately 40 by 90 miles. The asymmetry of the basin is evident in much more steeply dipping rock strata on the northeast edge of the basin than on the southwest. Paleocene and Eocene sediments (65 million to 53.5 million years ago, and 53.5 to 37.5 million years ago) filled the P.C. basin during its formation. These sediments were washed into the basin by streams flowing off adjacent uplifted land areas, the coarseness of the sediments generally reflecting the relative vigor of the uplift. Oil shales of the Eocene Green River formation accumulated in an extensive, fresh-water lake formed by an uplift that dammed the river drainage in early Eocene time. This lake had been largely filled with sediment by the late Eocene. A gentle uplift evidently assisted in its final draining, and in the re-establishment of a throughgoing river system. This change is reflected in the sandy sediments of the Uinta formation that form most of the caprock overlying the rich oil shales of the Green River formation. Except for the Thirteen Mile Creek tongue of the Green River formation, exposed in a narrow, horizontal band about half way up the breaks of Piceance Creek, the Uinta formation is the only rock unit exposed at the surface of the Horse Draw site.

The study area falls within a region of shallow, rocky soils, and deep, moderately dark-colored upland soils. These include about 60% lithosols (Haplorthents), 25% brown soils (Haplargids and Camborthids), 5% alluvial soils (Haplorthents), and 10% outcrop, badlands, gullies, and solonetz soils (Natrargids) (U.S. Soil Conservation Service).

Shallow, stony soils tend to predominate in steep canyon breaks, with deeper soils in footslope positions. Deep, rather dark, loamy soils prevail on the gentler uplands. Erosion potential is highest on rolling upland divides, wash banks and heads, and along roads and trails, especially on steep, upland slopes (U.S.S.C.S.).

b. Climate

Annual precipitation averages 12 to 16 inches, with 6 to 8 inches falling during the 5 summer months from May through September. About 60% of the annual total falls as snow. Mean annual temperature is about 47°F, and the growing season is bout 100 days (U.S.S.C.S.; U.S. Weather Bureau).

c. Vegetation

The Horse Draw site lies within Natural Vegetation Region 7a (Woodlands of the Intermountains) of the U.S. Soil Conservation Service for the state of Colorado. This region is characterized by pinyon and/or junier with wheatgrass, Indian ricegrass, and bluegrass mixed with various shrubs and forbs. Vegetative cover is sufficient to mask paleontological resources over much of the area.

d. Flora and Fauna

Flora of the uplands includes pinyon pine, Utah juniper, big sagebrush, serviceberry, mountain mahogany, snowberry, wheatgrass, Indian ricegrass, and bluegrass mixed with various forbs.

Flora of foothill swales includes big sagebrush, rabbitbrush, fourwing saltbush, basin wildrye, wheatgrass, Indian ricegras, squirreltail, bluegrass, yarrow, bladderpod, daisy, globemallow, Indian paintbrush, and wild buckwheat.

Flora of stony breaks include pinyon pine, Utah juniper, black, big, and fringed sagebrushes, serviceberry, rabbirbrush, wheatgrass, galleta, Indian ricegrass, needlegrass, Junegrass, and squirreltail.

Fauna may include man, mule deer, elk, cottontail rabbit, sage grouse, blue grouse, chukar partridge, pheasant, waterfowl, and many small rodents. Of these, only man has the potential for significantly impacting the paleontological resources of the site.

C. Adequacy of Current Reseach and Knowledge

Several neighboring areas of equivalent age and similar geology are fairly well known and understood. These include the Uinta basin of eastern Utah, the Hendry Ranch beds, located in a graben within the northern part of the Wind River basin in Wyoming, and the Sespe beds in southwestern California. Adequate vertebrate and invertebrate paleontological coverage of the P.C. basin has not yet been achieved.

D. Results of Investigations

1. Identities and Relationships of the Resources

a. Geologic Periods and Formations

All geologic formations exposed in the study area are of Eocene age. The lake bed shales, marls, and oil shales of the Green River formation, of lower, middle, and upper Eocene age, underlie river sands of the upper Eocene Uinta formation in this area. At the Horse Draw site, only the Thirteen Mile Creek tongue of the upper Eocene part of the Green River formation is exposed at the surface, interstratified between the Uinta Formation Tongue 4, below, and the Uinta Formation Tongue 5, above (Duncan, et al., 1974; Duncan, 1976). All three units are fossiliferous in the Horse Draw project site, but only Uinta 5 seems to be important for fossil vertebrates.

b. Types of Specimens

Fossil leaves are common in all three units. Those from Uinta 5 may be important for two reasons: they are well-preserved, and fossil plants of late Eocene age are rare. Among the most significant finds of this survey is the presence of fossil insects in the upper part of Uinta 4. Up to this time, no late Eocene insect localities were known in the United States. The preservtion of the specimens recovered during the survey was not particularly good, but it seems likely that better preserved material could be present.

Within Uinta 5, fossil vertebrates are fairly common in a zone that begins about 30 meters above the contact with the top of the Thirteen Mile Creek Tongue of the Green River Formation, and extends upward to about 60 meters above this contact. The bones are of large mammals, such as Brontotheres and Tapiroids, mainly preserved within a mudball conglomerate lithology of the Uinta Formation. Where exposures are good, one can expect to find one catologueable bone for every 300 to 400 meters of outcrop.

The descriptions of the paleontological sites are given in Table 1.

2. Site Locations and Concentrations

These are given in Table 1 and shown on Figure 2 taken from the U.S.G.S. geologic map of the Square S Ranch Quadrangle.

TABLE 1

SUMMARY DESCRIPTIONS, EVALUATIONS AND LOCATIONS OF THE PALEONTOLOGICAL RESOURCES

Site Number	Geological Formation & Period	Types of Resources	Condition of Preservation	Level of Importance *	Legal Description
BOM P-No.	1-8 All Eocene Vertebrate				
V_1	Uinta 5	Brontothere tooth + bone fragments	Moderate	III	Information omitted from public copies to protect sites from unauthorized collecting
V_2	Uinta 5	Bone fragments	Poor	IV	
V_3	Uinta 5	Brontothere Skull, not collected	Moderate	I	
V_4	Uinta 5	Brontothere Skull, not collected	Moderate	I	
V_5	Uinta 5	Foramen Magnum	Poor	IV	
V_6	Uinta 5	1) Teeth in rock, not collected 2) Isolated tapiroid tooth	Moderate	III	
V_7	Uinta 5	Limbbone, not collected	Good	III	
V_8	Uinta 5	Limbbone, not collected	Good	IV	

TABLE 1
(Continued)

Site Number	Geological Formation & Period	Types of Resources	Condition of Preservation	Level of Importance *	Legal Description
BOM P-No.	Pleistocene or recent Alluvium				
	Vertebrate				
V_9	Uinta 5	Bison Skull	Poor	IV	Information omitted from public copies to protect sites from unauthorized collecting
V_{10}	Uinta 5	Bone Fragments	Broken	IV	
V_{11}	Uinta 5	Bone Fragments	Broken	IV	
	Invertebrate				
I_1	Uinta 4	Insect larvae	Good	III	
	Paleobotanical				
P_1	Uinta 4	Fossil Plants	Poor	IV	
P_2	Uinta 4	Fossil Plants	Poor	IV	
P_3	Uinta 4	Fossil Plants	Good	I	
P_4	Uinta 5	Fossil Plants	Good	I	

TABLE I
(Continued)

Site Number	Geological Formation & Period	Type of Resource	Condition of Preservation	Level of Importance *	Legal Description
BOR I-19	Pleistocene or recent Alluvium Veterans				
V8	Unita 5	Bison skull	Poor	IV	Information omitted from public copies to protect sites from unauthorized collecting
V10	Unita 5	Bone Fragments	Broken	IV	
V11	Unita 5	Bone Fragments	Broken	IV	
	Invertebrate				
C1	Unita 4	Fossil Leaves	Good	III	
	Paleobotanical				
P1	Unita 4	Fossil Plants	Poor	IV	
P5	Unita 4	Fossil Plants	Poor	IV	
C3	Unita 4	Fossil Plants	Good	I	
P3	Unita 5	Fossil Plants	Good	I	

TABLE 1
(Continued)

Site Number	Geological Formation & Period	Types of Resources	Condition of Preservation	Level of Importance *	Legal Description
BOM P-No.	Pleistocene or recent Alluvium Paleobotanical				
P_5	Uinta 5	Fossil Plants	Good	I	Information omitted from public copies to protect sites from unauthorized collecting
P_6	Uinta 4	Fossil Plants	Poor	IV	
P_7	Green River 13m. creek	Fossil Plants	Poor	IV	
P_8	Green River 13m. creek	Fossil Plants	Poor	IV	
P_9	Green River 13m. creek	Fossil Plants	Poor	IV	
P_{10}	Uinta 5	Fossil Plants	Poor	III	
P_{11}	Uinta 4	Fossil Plants	Poor	IV	
P_{12}	Green River	Fossil Plants	Poor	IV	

* I-highest, IV-lowest

Figure 2 omitted from public
copies to protect the site locations
from unauthorized collecting
of paleontological resources

3. Present Condition of Preservation

See Table 1.

E. Resource Evaluation

1. Importance to Current and Future Research and Preservation Interests

The upper Eocene was a time when many important changes were going on in the evolution of mammals. Much of the recent research on this time interval has concentrated on small mammals, notably in central Wyoming and southwest California, and not much has been done to amass large mammal remains from this age since the building of the Chicago Museum collections before World War I.

2. Potential to Provide Further Information

This survey has demonstrated the likelihood of further significant finds of fossil plants, insects, and large mammals of the upper Eocene within the rock units exposed in the Horse Draw site. A detailed exploration of the region peripheral to the Bureau of Mines concession should produce a scientifically valuable collection of late Eocene vertebrates. In the interest of preserving this sinificant scientific heritage, the material remaining in the field should be collected as soon as possible.

F. Contribution of the Investigation

We have shown with the present survey that significant amounts of scientifically important late Eocene fossils are present and recoverable in the P.C. basin. Most notable among these are plant, insect, and vertebrate taxa of this age, which promise to fill an important gap in our present knowledge.

IV. Impacts on the Paleontological Resoruces

A. Adverse

1. Direct

a. Construction Related

The most obvious construction-related impact would be damage to fossils in that part of the Uinta Formation tongue 5 between 30 and 60 meters above its contact with the Thirteen Mile Creek Tongue of the Green River Formation.

b. Operation Related

The principal operation related impact would be direct access by construction and mining personnel and equipment to fossil resources under conditions that would be difficult to monitor. Visitors to the mine area would also come under this category.

2. Indirect

Increased susceptibility of the fossil resources to weathering and erosion subsequent to surface disturbance would be the principal indirect impact.

B. Beneficial

The principal benefits to accrue from this development will be increased knowledge and understanding of the presence of late Eocene (Uinta 5) mammals in the area, and of the location and nature of late Eocene plant and insect localities.

C. Cumulative

1. Project Specific

None are anticipated beyond those mentioned above.

2. Project, Environmental, and Social

Over a long period of time, sporadic and haphazard collecting by the nonscientific community may seriously erode the paleontological resources. Unmonitored collecting constitutes a significant loss of research and exhibit material to the scientific community.

VI. Unavoidable Adverse Impacts to the Paleontological Resources

Excavation of the shaft may have impacted many fossil plant and possibly insect remains, and a few fossil vertebrates -- mostly fish. Similar fossils may be encountered during excavation of the research chambers. Since equivalent plant and insect remains are probably present in the same rock units outside the BOM project site, the resultant loss to science should be small.

Adverse impacts may be expected when and if shaft and research chamber excavations encounter a stratigraphic level where fish are exceptionally well preserved. Such levels are known in the P.C. basin, notably in Garfield County. They are of scientific importance because the Green River Formation in this basin is slightly younger than it is in better known localities in Wyoming, such as Fossil Butte National Monument. Detailed studies of well-preserved fish from the P.C. basin may therefore be valuable in understanding the evolutionary history of some of the Eocene fish lineages. When and where shaft excavation may encounter levels of well-preserved fish is hard to predict, but salvage would be practically impossible under these conditions, and the resource would be lost.

VII. Short-Term Uses of the Paleontological Resources vs. Long-Term Benefits

Fossils occurring in the region will eventually be destroyed by natural causes or vandalism if left in the rock. The best short- and long-term salvation for the materials of better quality is their prompt and careful removal, so that they can be studied by scientists and made available, in exhibits, to the general public. None of the resources is valuable enough to warrant the considerable expense of creating an on-site exhibit and providing for its maintenance.

VIII. Irreversible and Irretrieveable Commitments of the Paleontological Resources

Unlike grass, which continues to grow after cutting, fossils once destroyed cannot be reconstructed. Those lost can often be replaced by others of the same species, but the existing population is reduced, and so, therefore, is the potential of understanding the parameters of that population. The paleontological potential of any formation is finite, though it may range from null to superabundant. Fossil vertebrates are always less abundant than fossil invertebrates. In both cases, those preserved in the rocks at any one time certainly amount to only a small fraction of one percent of the animals that existed at the time of their death. This original loss is compounded by the natural processes of weathering and erosion occurring through time. In order to achieve the best possible research and teaching potential for present and future generations, we must consider the need to protect what remains of our already fragmented paleontological heritage through proper collection and curation of valuable specimens.

Fossils are often unavoidably destroyed during construction. In many cases, the resulting loss to science is not significant, but in those areas where high impact will affect strata which are likely to contain valuable and rare fossil vertebrates, on-site monitoring should be undertaken with the objective of rescuing at least a representative sample of the resource to be destroyed.

In our opinion, the paleontological resources of the BOM pilot project are not important enough to justify cancelling the proposed construction, but we do believe that the Uinta Formation Tongue 5 should be carefully monitored if the project is expanded in these areas. We base this recommendation primarily on the known presence of fossil mammals in the unit, and on the general lack of data on the paleontology of that part of the Uinta Formation that lies within the P.C. basin. Although we do not yet know how the various tongues of the Uinta Formation in the P.C. basin correlate westward with the lower part of the Uinta Formation in the Uinta basin, the chances are excellent that much of the Piceance Creek beds are equivalent to the Uinta A beds of the Uinta basin. This latter unit is generally unfossiliferous (Cashion and Donnel, 1974, p. G6), therefore, any fossil mammals that could be collected from the Uinta beds of the P.C. basin would help to fill a significant gap in knowledge.

A. Glossary

Brontothere: A fossil Perissodactyl (q.v.) common in Eocene rocks.

Classification: A convention for ordering fossil and living plants and animals into a genetic hierarchy, generally arranged as follows (major to minor):

	(Examples)
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Perissodactyla
Family	Brontotheriidae
Genus	Palaeosyops
Species	paludosus

Eocene: A time unit in the Tertiary Period following the Paleocene and before the Oligocene. In absolute time, some 56 to 38 million years before the present. This time interval, itself, is referred to as the Eocene Epoch, and the rocks deposited in that time belong to the Eocene Series.

Formation: A mappable geologic unit which is distinct in character from the units above and below it. Such units usually have wide extent.

Intrusive: Cut into, either from above or below.

Invertebrata: Animals without backbones.

Lithology: The particulate composition of a rock; e.g., a sandstone is composed, lithologically, of cemented sand.

Perissodactyl: An odd-toed ungulate mammal. Living examples are horses, rhinoceroses, and tapirs.

Rodent: A gnawing mammal of the Order Rodentia. Living examples are rats, mice, and squirrels.

Tapiroid: Pertaining to those groups of taxa that are related to the tapirs. The only living species are tropical, found in South America and Indonesia. A type of perissodactyl.

Taxon (pl. Taxa): A unit of the biological classification system without regard to the size or rank of the unit (a species is a taxon, and so is a genus).

Vertebrata: Animals with backbones.

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